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Command and Control Systems Requirements Analysis

Volume 1
The Hierarchy of Objectives Approach

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ADMINISTRATIVE INFORMATION

The work reported herein was conducted for the Deputy Chief of Naval Operations (Naval Warfare) during FY 90 as part of the Naval Warfare Analysis Program. This document presents the results of a collaborative effort involving Science Applications International Corporation (SAIC) and Naval Ocean Systems Center (NOSC), Code 171, Systems Analysis Group, personnel.

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COMMAND AND CONTROL

SYSTEMS REQUIREMENTS ANALYSIS

VOLUME 1

THE HIERARCHY OF OBJECTIVES APPROACH

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SECTION 1.0 INTRODUCTION

Military and Naval Operations are a complex set of activities involving organizations of people and equipment in conflict with another such organization. Analysis of the overall effectiveness of the opposing forces is a difficult task. Part of the problem is the enormous complexity of the interaction. Another difficulty is the lack of means to evaluate the contribution of Command and Control (C2)* to the eventual outcome.

Descriptions of large scale complex systems are very difficult to derive because of the many levels and frames of reference required for understanding. These many levels are necessary because of the nature of the problem and because we are limited in our ability to comprehend more than a few aspects of a problem at the same time. The concepts being presented here will not make the problem simple, but some simple tools will be provided, which, when applied consistently, can be used to gain insight into the problem and, when applied repetitively, iteratively or recursively, can be used to describe a complex system in more manageable terms. These insights are based on common sense and well-known ideas, but this presentation provides a framework of conventions to clarify relationships and identify similarities and differences among a few fundamental concepts about the nature of systems. The role of decision making in systems is also stated in a way that can be applied to all aspects of the problem.

1.1 BACKGROUND

Naval Warfare needs are described in a series of Top Level Warfare Requirements (TLWRs) documents. TLWRs have been developed by the Office of the Chief of Naval Operations (OPNAV) for some Warfare Mission Areas (WMA), as well as for Electronic Warfare (EW) and for the Carrier Battle Force (CVBF). TLWRs are now being addressed at an even higher level, that of the Functions of the Navy, beginning with Sea Control and, subsequently, for Power Projection.

The TLWRs for Sea Control are expressed in terms of Mission Success Criteria (MSCs). These are statements of objectives to be achieved in various mission situations. The ability to achieve the MSCs is expressed as a combination of Required Capabilities (RCs) in the various WMAs. The RCs are, in effect, sub-objectives that would lead to the accomplishment of the MSCs. In the TLWRs for WMAs, these RCs become MSCs and, to support them, there is a set of RCs for platform mobility and sensor and weapon systems. C3I requirements have been stated subjectively in qualitative and quantitative terms in the TLWRs and other references, but not in a way that exhibits the contribution of C3I to Warfare goals.

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* For the purposes of this report, the acronyms C2, C3, and C3I will generally refer to the processes of Command and Control (C2), Command, Control, and Communications (C3) and Command, Control, Communications, and Intelligence (C3I), while the word "systems" will be appended if necessary to distinguish physical resources from the processes. C2 involves decision making and the total information processing that supports it. C3 adds the information exchange process among decision-making elements. C3I represents an emphasis on processing and exchange of Intelligence data within the C3 process, not on the collection of Intelligence data. Similarly, the Surveillance data collection is not included within every C2 process, unless it is the Mission of that element.

Within the organization of the Deputy Chief of Naval Operations for Naval Warfare, the Director, EW, C3I, and Space Warfare (OP-76) is responsible for the C3I Warfare Support Area Appraisal, a major component of the Navy's Planning, Programming, and Budgeting System. OP-76 is also responsible for the administration of Team "C", which is guiding the development of the Navy's Battle Management C3I Master Plan. OP-76 is evolving a methodology for analyzing C3I Warfare requirements in support of these efforts. Previous work has resulted in a C3I Operational Requirements Framework (reference (g)), hereafter referred to as the Framework, and the conduct of Workshops on Tactical C3I Requirements and Deficiencies for Power Projection and Sea Control. This task is intended to extend and enhance the Framework in support of the next cycle of assessment and master plan development.

Within the Space and Naval Warfare Systems Command, the Warfare Systems Architecture and Engineering (WSA&E) Directorate (SPAWAR-30) directs the development of architectural descriptions and assessments of current and future Naval Warfare Systems. The process is governed by the issuance of the TLWRs by OP-07. In response, the Architecture team is attempting to devise a means of providing a traceable accounting of the relationship between system performance and the TLWR. This has given rise to the development of a methodology for Architectural description, modeling, and assessment that is ongoing. This methodology addresses Operational Functions, System Capabilities, and Force Performance Measures. The Warfare Mission Support Areas Division (SPAWAR-312) has solicited the Naval Ocean Systems Center (NAVOCEANSYSCEN) to lead a team of Navy Laboratories to address C3I Architecture issues. This report provides support and guidance in coordination with that effort.

The first objective was to develop a hierarchical multi-level analysis structure of functions and metrics, down to the Force level, that relates Operational Functions and Resource Capabilities to Mission Success Criteria, Required Capabilities, and Force Performance Measures, and describes how these depend on Mission context. The analysis structure makes evident the contribution of C3I, embedded in the operation, to effect Mission Success. The first volume of this Technical Document, subtitled The Hierarchy of Objectives Approach (reference (c)), addresses an approach to functional analysis of Naval Warfare at the top levels, addressing military objectives and mission area characteristics to the intra-task force level, with a focus on how C2 affects results. The second volume, subtitled Measuring C2 Effectiveness with Decision Probability (reference (d)), presents methods for mathematically relating capabilities and objectives at those levels. This metric analysis is based on a common measure (conditional probability) to quantify the effect of dependency among functions at all levels of the hierarchy. The probability of making a decision affects what activities will take place, which, in turn determine what outcomes will occur.

This volume (vol. 3) focuses on functional and metric analysis at the system level, in particular, for C3I systems. System Functions support Operational Functions, including Command Process Functions, and are supported by Equipment Functions. Equipment Functions are also addressed.

1.2 OVERVIEW OF APPROACH

1.2.1 Role of Hierarchy of Objectives

A Hierarchy of Objectives can be stated in terms of Missions, Functions, and Tasks. For a particular Force or System, its Functions are the activities it performs in order to accomplish its Mission. Its Tasks are its subfunctions, which are performed by its parts or subsystems. Mission objectives are based on achieving a preferred set of outcomes, which are particular states of the enemy's forces and ones' own, as well as the state of the environment, e.g., occupied territory. These objectives may support a higher objective, such as the capitulation of the enemy. The strategies, operations, tactics, and procedures used by each Force are a hierarchy of functions or processes that correspond with their hierarchy of objectives. The sub-objectives are to achieve

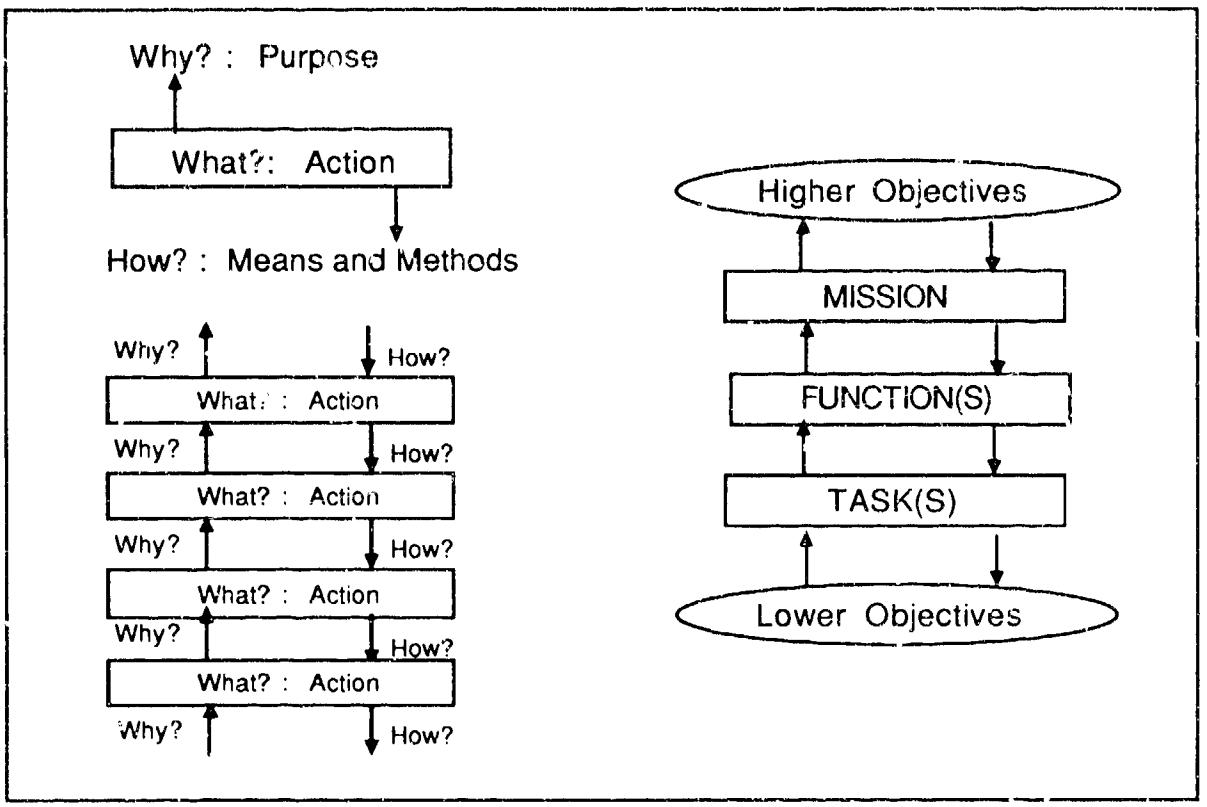

Figure 1. Generic Hierarchy of Objectives

This simple picture masks the complexity of the true interrelationships of functions. A true functional decomposition is not a pure tree and may not be strictly hierarchical. There may not be distinct levels or uniform depths of decomposition. Rather than a tree, a functional structure is more properly represented by a graph. (In a tree, each node has only one predecessor; in a graph it may have more than one.) If it is strictly hierarchical, a multiplicity of functions at one level may support or be supported by a multiplicity of functions at another level. Then again, it may not be hierarchical, in that a function may support functions at more than one higher level or there may be cyclical or mutually supportive purposes, such as sinking submarines in order to protect supply ships that provide logistic support in order to sustain operations to sink submarines. The interdependence or lack of strict ordering of functional relationships must be accommodated. This can be accomplished by simultaneous and higher order relations, as long as causal and consistent temporal ordering are maintained. For the purposes of this report, the word will be loosely interpreted as an ordering without strict layering.

1.2.2 Functions and Outcomes

Another useful concept, which has evolved from the Joint Directors' of Laboratories (JDL) C3 Research Program (references (e) through (h)), describes functions in terms of their outcomes (output events) and the events that influence those outcomes. The consequent events (outcomes) of a function are said to be conditioned on its antecedent events (causes and influences). The conditioning, in this case, is a statement of cause and effect. Since a function is a set of tasks, its outcomes and influences can be expressed as combinations of the outcomes and influences of its tasks (subfunctions). Given a hierarchy of functions and their associated events, the conditioning relationship can be used to build a causality net (or graph), which represents the cause and effect

structure of the activities. Outcomes of one or several functions are the influences of other functions. This represents a chain of events that is an interwoven set of functional event sequences. For Military Operations, this structure must be built for the interaction of two sides and an intervening environment. This concept will be introduced here and explained in more detail in the subsequent report. Reference (h) describes the application of this concept to a combat model that explicitly incorporates the effects of decision making.

1.3 ORGANIZATION OF REPORT

The following section delineates some concepts and definitions for describing systems that apply to any analysis. These fundamental concepts can be applied to any portion of a system or its whole. The context for appreciating the purpose of Command and Control, and its supporting C3I systems, is established in the Mission-related Hierarchy of Objectives provided in section 3. The decision-making process that enables the activity of the remainder of the system is described in section 4 by an overview of the Command Functions, which are specified in more detail in Appendix A. Features of this Command Process Model are compared to other decision paradigms and some concepts concerning the nature of decision making are discussed.

The time to accomplish these functions is inherently included in these requirements, often in terms of "timeliness". Component times may involve:

Time to obtain data,
Time to generate picture,
Time to recognize situation or need to replan,
Time to decide on course of action and resource allocation,
Time to promulgate decision, and
Time to replan.

With these types of C3I measures in place, along with Mission-oriented requirements measures, the overall outcome can be assessed with a view into the contribution of C3I, since the activation of Warfare Mission Area functions is conditioned on the direction to carry them out. The time to carry them out will not begin until they are initiated. Therefore, the achievement of the objectives depends on the probability of activation and the time to initiate action. This is explicitly the connection between C2 performance and the completion of Mission objectives.

1.2.6 Classes of Functions

The primary ingredient in describing a system is understanding its purpose. The primary or ultimate purpose is its Operational Function. There is a lot of necessary or unavoidable activity in a system which may also be called functions. These may not be considered the primary purpose of the system, but they are functions. It is useful to describe several classes of functions: Operational Functions, System Functions, and Equipment Functions.

Operational Functions are derived from the Mission that the system is supporting. System Functions are tools that assist in the accomplishment of the Operational Functions. These are the subject of this document and will be elaborated in detail. Equipment Functions provide the means to accomplish the System Functions.

The role of the decision function was discussed in the Hierarchy of Objectives. Since decisions enable all other functions, there are varieties of decision functions in all the classes of functions. The Command Process Model addressed decision functions as Operational Functions. This document will describe the C3 System and Equipment Functions that support the Command Process Functions. C3I System and Equipment Requirements must be based on the ability to perform the System and Equipment Functions and related to the probability of making decisions.

1.3 ORGANIZATION OF REPORT

Having presented an overview of the approach taken in these studies, an expansion of these ideas is included in section 2.0. This lays the groundwork for the presentation of a method for defining System Functions and Equipment Functions in section 3.0. A discussion of some ideas and issues about the way C3 systems are designed are provided in section 4.0. The factors that need to be considered in assessing C3 systems are discussed in section 5.0. Section 6.0 presents references.

or tactics depending on the scope of the activity being addressed. Plans, directives, rules, and instructions delineate these procedures.

Processes may also include what is being done to a system by external influences. Thus a process involves the internal functions of the system and the functions of other conditioning effects. For example, turning on a radar will not have the desired effect of detecting targets, if there is jamming in its band, unless it has anti-jam (AJ) functions that are activated. The performance will depend on the conditions of the jamming, as well as on the AJ effectiveness. Often, "function" is used only to mean what is done by the system, while "process" includes what is done to it, as well. Both conventions will be used, here, because the metric analysis will define functions as depending on all conditions or results of relevant processes.

The word, "function" therefore can mean either process or purpose. In fact, the same function can mean both, depending on whether, in the Hierarchy of Objectives, it is being viewed from above or below, respectively.

2.2 ELEMENTS: RESOURCES AND OBJECTS

In addition to processes, elements are the other principal aspect of system analysis. Any object or entity, be it a system, weapon, platform, force, or person, is an element or resource of the overall system being analyzed. The System may be any collection of subsystems or elements. The overall System to be analyzed must be contrasted with and related to the environment, background elements and opposition elements. All of the latter are part of the context described below. The System of interest embedded in its context also constitutes a system.

An element is synonymous with the functions or processes it is capable of performing or experiencing. If it did other things or had different properties, it would be a different thing. Only its particular identity is unique.

2.3 ATTRIBUTES OF ELEMENTS

Attributes of an object or element are its physical properties, characteristics, qualities, and, in general, its state or condition. These may include size, color, position, course and speed, number of weapons, number and type of platforms, damage condition, activation status of equipment, information state, etc. Each attribute can take on a range of values, and thus can be considered a dimension of the description of the element. Aggregate states or outcomes are combinations of attribute values, or even collections of them, such as "all values above 37". Aggregate states can also apply to aggregate elements, such as "number of platforms of the force in the survival state". The survival state of each platform is part of the state of the aggregate force. The goal of the two sides in the conflict is to achieve an aggregate state of friendly and enemy forces, as well as the environment, that is advantageous to their side.

A special attribute of an element is its identity, such as, name, number, type.

2.4 OUTCOMES AND ATTRIBUTES

The set of outcomes of a process that involves an element are identical to the set of values of the attributes of the element. That is, a particular outcome is a specific state of that attribute dimension. In a sense, attributes and outcomes are synonymous. Events are synonymous with outcomes if we

include the idea that a condition at a point in time is an event, whether or not a change in state or attribute is involved.

2.5 OUTCOMES AS RESULTS OF PROCESSES

An often cited paradigm to describe system operation is Input-Process-Output. This view neglects the change in internal state that may occur in the processing system. Although the process is the causal relationship between the input and the output, it is also dependent on the current (prior) state and is governed by a set of rules (procedures). The rule activation (decision) requires knowledge of the input and the current state. As a result of the process, an output is produced and the state of the system may change. The outcome is the output and the resultant state. An approach is needed to capture these ideas of inputs, outputs, states, rules, and decisions associated with a system. The approach taken in references (e) through (h) describes a system or node in terms of Stimuli, Decisions, States and Responses. A variant of that approach will be used here. (Figure 2, General Process Model, is a representation of this method.)

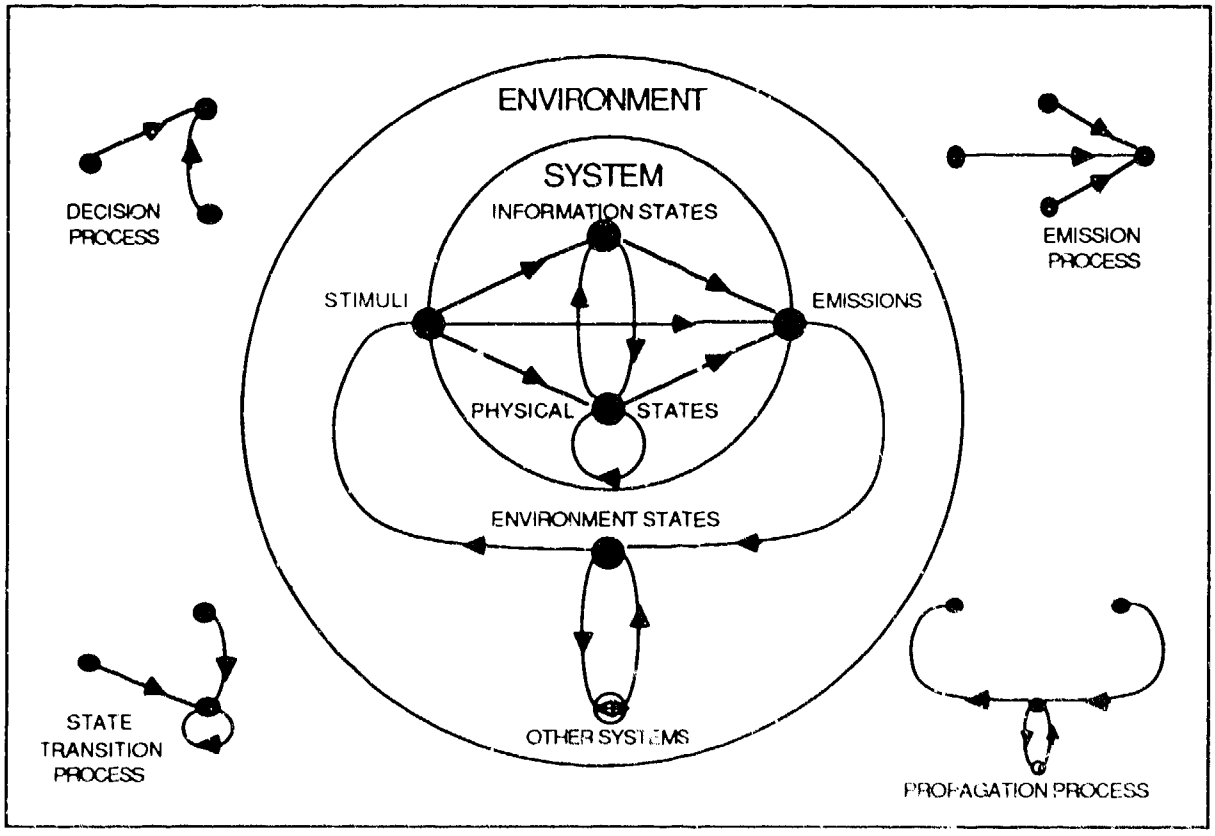

Figure 2. General Process Model

The idea of Stimulus-Response is very familiar, but it is not always the case that the Response is an emission or outward reaction. It may also be that there is a physical state change in response to the stimulus. There could also be a new decision, which may be referred to as an information state change. This suggests that there are three kinds of outcomes (or responses) to consider: Decisions, State changes and Emissions. In figure 2, the classes of outcomes are represented by black dots (or nodes of a graph). They are connected by arrows that indicate a dependence of the

node at the head of the arrow on the nodes at the tail. Of course, Decisions (Information States) can only be affected by information stimuli, which may arrive by wave (electromagnetic or acoustic) or tangible (e.g., paper) media, and by information about the Physical and Information States of the system. Physical States are affected by concrete (e.g., projectiles) or wave (e.g., EMP) Stimuli, by Decisions and by other Physical State outcomes. Emissions are likewise the result of Stimuli, Decisions, or Physical State effects. The Emissions also may be wave or concrete in nature, but can carry information, too.

To close the loop, the Emissions propagate through the Environment to possibly become Stimuli to other (or the same) parts of the system, including the allied, opposition and neutral elements. The Emission represents a change of state of the environment at the location of the emitting node. The function of the Environment is to propagate the effects of the Emissions to other locations, which changes the environmental state at those locations. Any node at those locations is a candidate to be affected by the state of the Environment. The effect is a Stimulus. Weapons, or even whole Battle Forces, can be treated as propagated emissions if the level of analysis is not focussed on their internal states.

Each set of outcomes that constitute a kind of Stimulus, Decision, State, or Emission is the result of so process or function that is driven by another group of outcomes of other functions. Thus a fun n or process is a relationship between outcomes, or equivalently a relationship between states of a system or element. This relationship is a causal conditioning. The antecedent events cause the outcomes in a way defined by the rules of the function or process. The small subgraphs in figure 2 represent the Decision-, State-, Emission- and Stimulus-producing processes, the latter being propagation through environmental state transition processes.

2.6 IDENTIFYING FUNCTIONS BY OUTCOMES

Another difficulty in system description is in the identification and naming of functions. Part of this problem is the synonymous use of words, as discussed above. Specifically, when the scope of analysis changes, the name of a higher level function may be the same as that of one of the lower level functions, particularly the last one in a sequence of subfunctions. For example, the function "Kill" may be decomposed into "Detect, Classify, Track, Close, Attack, and Kill".

Sometimes, functions are called by the name of their set of outcomes, such as "Classify". More often, they are named by the favorable outcome, e.g., "Detect". This ignores the unfavorable outcomes, like missed detections and false alarms, as well as the valid outcome of non-detection, when there is nothing to detect. The function name that covers all these cases is Search. It would be preferable to use a word that allows for all the outcomes and conditions on which they depend. Note, in the example, above, the function "Kill" is named after the favorable outcome. In this case, the better name would be Attack. This would leave room for the outcomes of Kill, Injure, or Miss. Of course, these outcomes involve the effects of the environment and enemy actions.

In identifying a function, there are two ways to clarify its meaning. One is to list its subfunctions. Another is to specify its outcomes and the events that are its antecedents. The first approach may be useful, but at some point, it may be necessary to resort to the latter method in order to clarify the subfunctions. Making a list of products or outcomes may be the best and necessary way to terminate functional decomposition. In fact, a system description is not complete until this has been done at every level of the hierarchy. The outcomes at higher levels may be the same as those for a lower level, particularly when there is a single subfunction at the end of a chain making up the higher level function. Otherwise, the higher level function must have a set of outcomes that are aggregates of the lower level outcomes. The antecedents of a function must also be consistent aggregates of the antecedents of its subfunctions. Thus, the relationship of functions and outcomes is inseparable. They are two sides of the same coin.

2.7 ORGANIZATIONAL ENTITIES AND ROLES

Organizations consist of an interactive network of people (human resources) using other resources to carry out roles, which are combinations of functions they are responsible to perform. Each organizational entity, such as a job or position, is an abstract element, synonymous with the role of that position. It has attributes, such as, authority, capacity and information state, and outcomes, such as decisions, which are changes in information state. These states and decisions may exist as data contained in human or computer resources.

2.8 DEFINING DECISION-MAKING OUTCOMES

The Command Functions, described below, were defined in a generic way so that the similarity of the decision process at any organizational level or in any mission area would be apparent. What distinguishes the various cases is the nature of the Warfare Functions whose outcomes are being controlled. The hierarchy of objectives must delineate what those outcomes are. The decision-making outcomes that represent the purpose of Command and Control are those that allocate resources to those Warfare Functions. The outcomes of the subfunctions of the decision-making process also need to be defined for the various cases to which the Command Functions are being applied. The antecedent events, i.e., information and directives, that trigger decision cycles, for a particular Organizational role, complete the definition of the Command Function for that case or context. In fact, the context also represents antecedent conditions that affect decision outcomes.

2.9 CONTEXTUAL CONSIDERATIONS

The context within which operations are performed is a strong determinant of the demand placed on systems and how they will perform. Principal contextual considerations include the Mission, including the Level of Conflict, and the environment.

The Mission statement is a context-setting vehicle, that influences which activities will be carried out or constrained. This includes the objectives and the rules of engagement. The quantity and quality of resources available are also influential.

Level of Conflict is a state of the world and the ultimate objective of opposing sides is to get to a minimum level of conflict, preferably with advantageous outcomes with respect to other states. This may entail going through a higher level of conflict in order to achieve those collective objectives. Mutually advantageous or mutually detrimental situations are included in the set of viable objectives.

The environment, itself, is an entity or object. It has conditions and states, and therefore, outcomes and processes. This treatment of the environment as an entity is described above and provides a basis for coupling systems through the environment and analyzing the combination with the same techniques used to describe them separately.

The Phase of operations and Season of the year are two temporal variants of the context. The Phase is related to the Mission and Plan; while Season is a condition of the environment.

Time is a special environmental or contextual attribute. It is a common factor to which all activity is referenced (the Theory of Relativity notwithstanding). Outcomes can only be defined relative to some time or time-frame, even if it is the proverbial "end" time.

2.10 BOUNDARY OF A SYSTEM AND ITS FUNCTIONS

When people disagree on the nature or functions of a system, it is often because they have individually defined different boundaries of the system. Since function names can be the same at different levels of the hierarchy, the confusion is understandable. By defining the elements that make up a system (a larger element) as well as its functions, states and outcomes, a boundary is established, which should lead to a better understanding of the system.

The boundary contains all the elements, including organizational entities, used to perform all the functions of the system. In a Hierarchy of Objectives, these Functions are the ones supporting the Mission of the system, while the functions of the elements are the Tasks of the system. The boundaries of the systems supporting two different missions may overlap, since some functions and elements may be included in both.

2.11 SUMMARY OF CONCEPTS

The previous discussion provides a way of describing systems with a few commonly defined concepts. First, that there are elements that are described by their states. Second, that the behavior of elements is embodied in processes that result in outcomes, which are realizations of a combination of states. Each process is a relationship between its antecedent events and its outcomes. Decision making is a special process that results in decisions, which are realizations of information states. Organizational elements are special elements that perform decision making functions. Some outcomes (emissions) propagate through the environment to become stimuli to various elements.

A function or process is fully defined when all its outcomes are defined and all its antecedent events are defined. If there are intermediate outcomes, these identify the boundaries of subfunctions. Thus, event sets decompose in a complementary way with their corresponding functions.

An object is fully defined when all its attributes are defined. This is synonymous with defining all the possible outcomes of its functions and therefore, it is defined by its functions. These are inherently concurrent definitions.

For purposes of a particular analysis, the previous statements may be modified to read: "A function or process is sufficiently defined when all its relevant outcomes and antecedent events are defined." and similarly for objects. Top level relevance is established for the outcomes related to the objectives of the analysis. Relevance is also determined by whether the events influence other relevant events or are necessary for connecting functions together.

By connecting together those events that influence other events or outcomes, the resulting graph represents a functional architecture of the system.

SECTION 3.0 A HIERARCHY OF WARFARE OBJECTIVES

A survey of the TLWRs for Sea Control, ASW, CVBF AAW, EW for ASW, and EW for AAW was conducted to provide a set of objectives that could be structured into a Hierarchy of Objectives. Figure 3, Hierarchy of Warfare Objectives, is a compact summary of the kinds of functions and relationships developed in the survey and is discussed below.

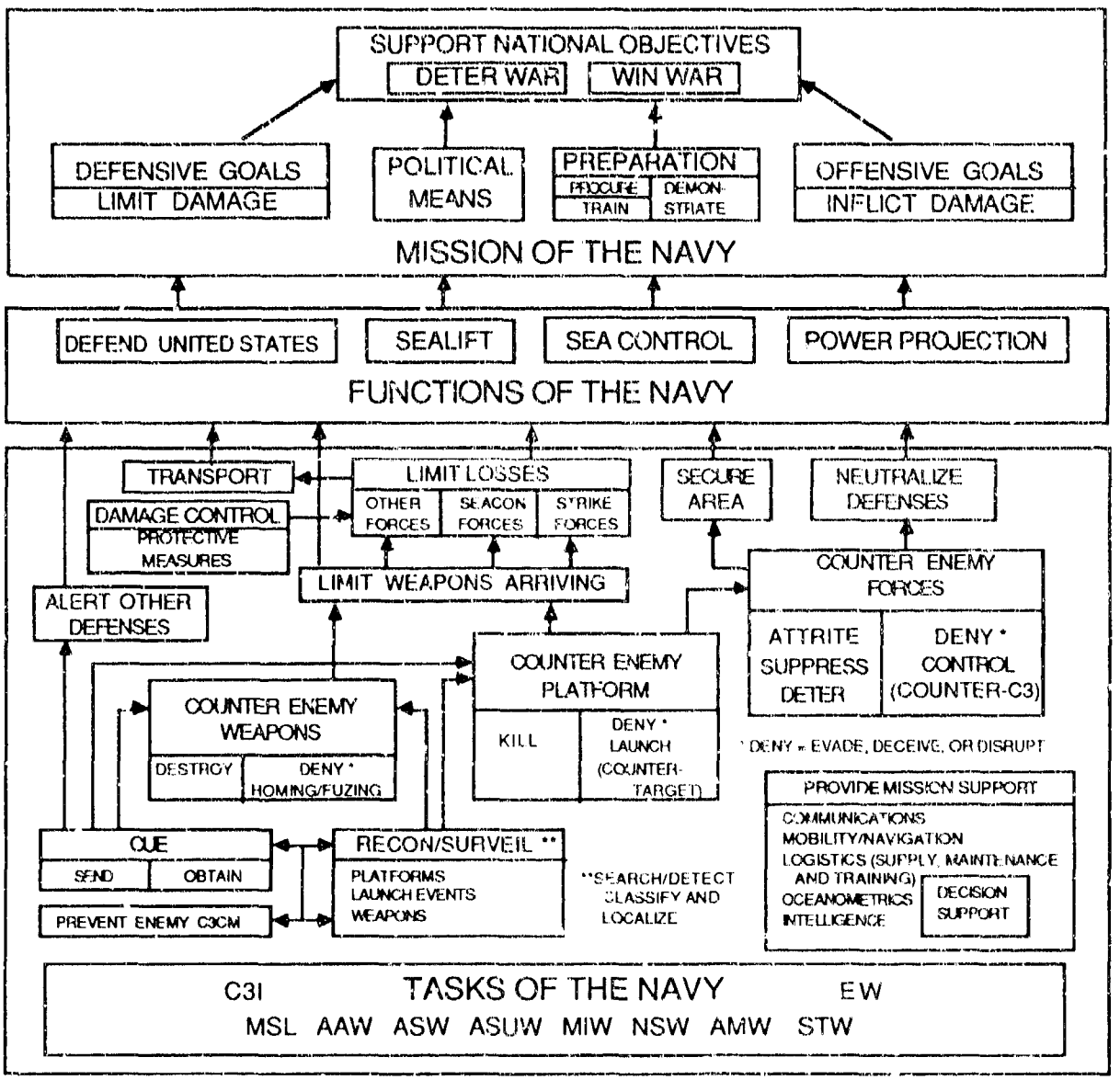

Figure 3. Hierarchy of Warfare Objectives

3.1 NAVAL WARFARE OBJECTIVES

By law, the Mission of the Navy is to "be prepared to conduct prompt and sustained operations at sea in support of U.S. national interests". The Top Military Objectives are to Deter War or, failing that, to Win War. There can also be Political and Economic Objectives, not shown. A second tier of National Objectives is shown. In addition to Offensive and Defensive Goals, there are Political and Economic means of Deterring or Winning War. Preparation is important for Winning, but also contributes to deterrence, if demonstrated.

The Functions of the Navy, which support National Objectives, are to perform Power Projection and Sea Control. Recently, the Navy has also been assigned the job of Sealift as a Function, and an unstated role has always been to defend the United States. Each Function of the Navy establishes a Mission for the Forces assigned to carry out that Function. This is the purview of TLWRs such as that for Sea Control. What are the Functions of those Forces? They are a combination of the Tasks of the Navy. The Tasks of the Navy consist of Warfare Tasks and Support Tasks. Among the Warfare Tasks (Warfare Mission Areas), for example, is Anti-submarine Warfare (ASW). Based on the hierarchy of objectives, therefore, the Mission of ASW Forces is to conduct ASW operations in support of Power Projection, Sea Control, Sealift and Defense of the United States. What, then, are the Functions of ASW Forces? This is the purview of the ASW TLWR. Similarly, the other WMAs constitute a level in the Hierarchy of Objectives. In this, they are mutually supportive. At the next level, they are supported by the Mission Support Tasks, among them C3I and EW.

The TLWR documents provide a host of MSCs and RCs that denote objectives that imply functions to be performed. The Sea Control TLWR RCs support its MSCs. These RCs can be identified with the MSCs for the WMAs. The lower level MSCs require support from the RCs at that WMA level. These criteria and capabilities will be addressed in more detail in the report on metrics. A general list of the kind of functions and objectives involved is shown within the lower half of figure 3. These functions are shown as sub-objectives of the Tasks of the Navy supporting the Functions of the Navy. The sub-objectives do not align themselves into layers or tree-like structures. Rather, they form a web of generally upward relations. The sense of the arrows, from tail to head, can be interpreted as saying, "Do this in order to accomplish that."

For a complete description, the outcomes of these objective functions, and their antecedents, must be defined for the situations or cases deemed to be important within the scenarios of interest.

3.2 RELATING MISSION (PRIMARY/SECONDARY), MISSION SUPPORT, C2, COMM AND RESOURCE FUNCTIONS

As we move down the Hierarchy of Objectives, a pattern emerges that reflects the multi-dimensional nature of system analysis. Mission functions may fall into importance categories of Primary and Secondary and usually a class of functions called Mission Support functions are identified. When we move down the Mission Support branches, these become objectives, too. While the main branch of functions are objectives (mission related), there is a set of functions needed to control the objective functions. In addition, communication functions must occur at every level, in order to enable the control. Control is the function that permeates all branches, as well as its two principal support functions, information gathering (surveillance, reconnaissance and intelligence) and information transfer (communications). Supporting all the functions are the things that the Resources can do. These, too, require control.

At this point it becomes apparent that the hierarchical structure does not proceed in one dimension. In particular, C3I is a function that supports the chain of command above the WMA level as well as at that level.

3.3 THE ROLE OF C3

There appears to be a concensus among the C3 community that the justification for C3 systems must be based on the combat or mission outcome (reference (i)). In other words, the effectiveness of decision making (and decision support systems) has no meaning outside the context of a mission or purpose. Conversely, the historical approaches to modeling and assessment of operational systems have implicitly assumed "perfect C3". This results in optimistic forecasts of performance, not an accurate model. In other words, the expected outcome of missions cannot be properly modelled unless the effect of decision making is included. These two complementary ideas suggest a synergistic relationship between mission analysis and decision analysis.

In fact, that relationship is one of cause and effect; the mission is not executed unless it is initiated by a decision to carry it out. In other words, it is the role of Command (decision making) to initiate required mission functions. This involves recognizing which functions are required or will be effective (or appropriate or authorized) and allocating available resources under its control to carry them out. Of course, the initiation must be accomplished in a timely manner, that is, early enough for the mission to be carried out before the enemy accomplishes its objectives, but not so early that more effective alternatives might be pre-empted.

The purpose of C3I functions, therefore, is to support the making and implementation of Command Decisions that activate or control the activities of Warfare Organizations and Systems. In a Hierarchy of Objectives, the Command Decisions occur at every level. The relationship of Command Decisions to Warfare Functions, at a given level, is that the former selects which of the latter to perform and to enable their implementation for the purposes of the next higher level. Figure 4, Decision in the Hierarchy of Objectives, shows this concept in an adaptation of Rahmatian's symbology from figure 1. The Hierarchy of Objectives is augmented with a Decision at every level. "What" objective function to perform is determined by the "Decide" at that level. "Why" it needs to be performed is established by the higher level objective(s) and is the motivation for the decision. "How" has the same meaning as before. At each level, the "Decide" function is further decomposed into the "Decision Functions" needed to make those decisions. We have called them Command and Control Functions for obvious reasons, but we also refer to them as Command Functions for short. These functions have been defined in the previous Framework document. An updated version of those Command Functions is provided in Appendix A, Command Functions, and they are summarized, in Section 4. The augmented Hierarchy of Objectives concept will be used to establish a set of relationships between Missions, Functions, and Tasks and the Command and Control activities that enable them.

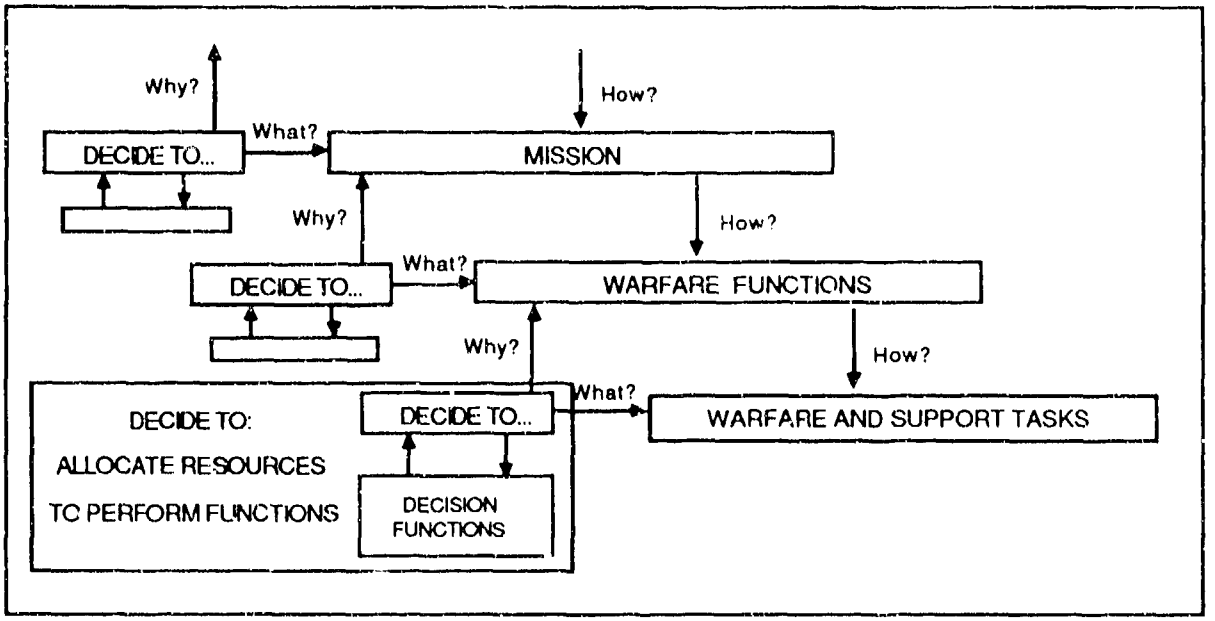

Figure 4. Decision in the Hierarchy of Objectives

Command Functions influence the implementation of Warfare Functions and are themselves influenced by the information available to them, including the plans, rules, procedures, and directives used to control an operation. Thus, C3 activity can be expressed in terms of decision making and of communicating information for and about decisions. The C2 (decision-making) outcomes are conditioned by the authority vested in the decision maker and the information about the situation that becomes available to the Command Functions. The communication outcomes determine that availability, conditioned on the generation of information by surveillance, reconnaisance, intelligence, and other C2 functions. Command Functions contribute a subset of objectives in the hierarchy, including Interpret Data, Delegate Authority, Allocate Resources, and Activate Mission (or Support) Functions. Communications support the objective of Conveying Data. C3I systems support these objectives by providing functions that organize, sort, transform, retain, transfer, and present data.

This perspective on C3 functions is fundamental, robust, and general. It provides the means to consider C3 embedded in the Operational Mission structure, which provides the proper context for C3 assessment. The enemy's capabilities are represented in the other half of the two-sided structure, including their C3 activity. Countermeasures for both sides are also representable in this structure. It provides the basis for the analytic description of the role of C3 functions and, in combination with platform, sensor, and weapon functions, yields a view of the interaction that combines to achieve higher level Functions and Missions.

SECTION 4.0 OVERVIEW OF COMMAND FUNCTIONS

The Command Functions in Appendix A are summarized in the following paragraphs. This summary provides an overview of the relationship of the functions among themselves and to the operations they control. These functions were derived from other models of the decision process and consolidates important features of those concepts. A discussion of those features is provided, to highlight those aspects of the Command Functions and to explain the role of those features in the structure of the decision process.

The Command Functions consist of four major functions: Plan, Observe, Assess, and Execute, sometimes abbreviated as POA&E. These one-word function names are used for ease of discussion. The four functions are almost identical with the functions of the Command Process Model in the previous OPNAV C3I Operational Requirements Framework document, except as noted below and in Appendix A. Additional functions of Sense and Act may be appended to the list to couple the other four to the physical world. The alternative functions of Receive and Issue (or Send) play a similar role in coupling to other decision-making activity.

The revised Command Process Model (CPM) is depicted in Figure 5, Command Process Model. The decision process, the heart of the Command Functions, is in the center, with the coupling functions around it. The left side collectively performs monitoring activities, while the right side constitutes the control portion. The main sequences of the decision process are shown by arrows. Information flows among the decision functions are not shown, but they are listed in the appendix.

Information obtained through the Receive function can be destined for any of the decision functions. In the appendix, these data are listed with the corresponding decision function. Information can also be obtained from the Sense function as an input to Observe. Information is transferred through the Issue function. This information is listed with the decision function which produces it. Actions being controlled are defined in the Act function. This includes control of the sensing function, which produce sensory inputs. It is not critical, whether Sense/Receive is viewed as a single function or as two functions. Likewise for Issue or Act. But there is a subtle difference, so they are shown separately.

4.1 OBSERVE

The Observe function combines information for use by other functions. This is an all-encompassing "data fusion" function. It involves not only storing data together, but also association, correlation, and tracking functions and compilations of Intelligence data and Force status information. This aggregate of information is often referred to as the Tactical Picture at the combat level.

4.2 ASSESS

The Assess function makes use of the combined data to infer meaning about the situation, including enemy intent and potential outcomes of unfolding events. This is the real product of Situation Assessment, not just the Tactical Picture produced by Observe. The assessment determines whether mission objectives are being achieved, a new or revised set of plans is required or a change of procedure under current plans is appropriate. If planning is required, the Plan function is invoked. If a change in procedure is suggested by the situation, the Execute function is notified and can change modes. Otherwise, Execution proceeds under the current mode, using information from Observe.

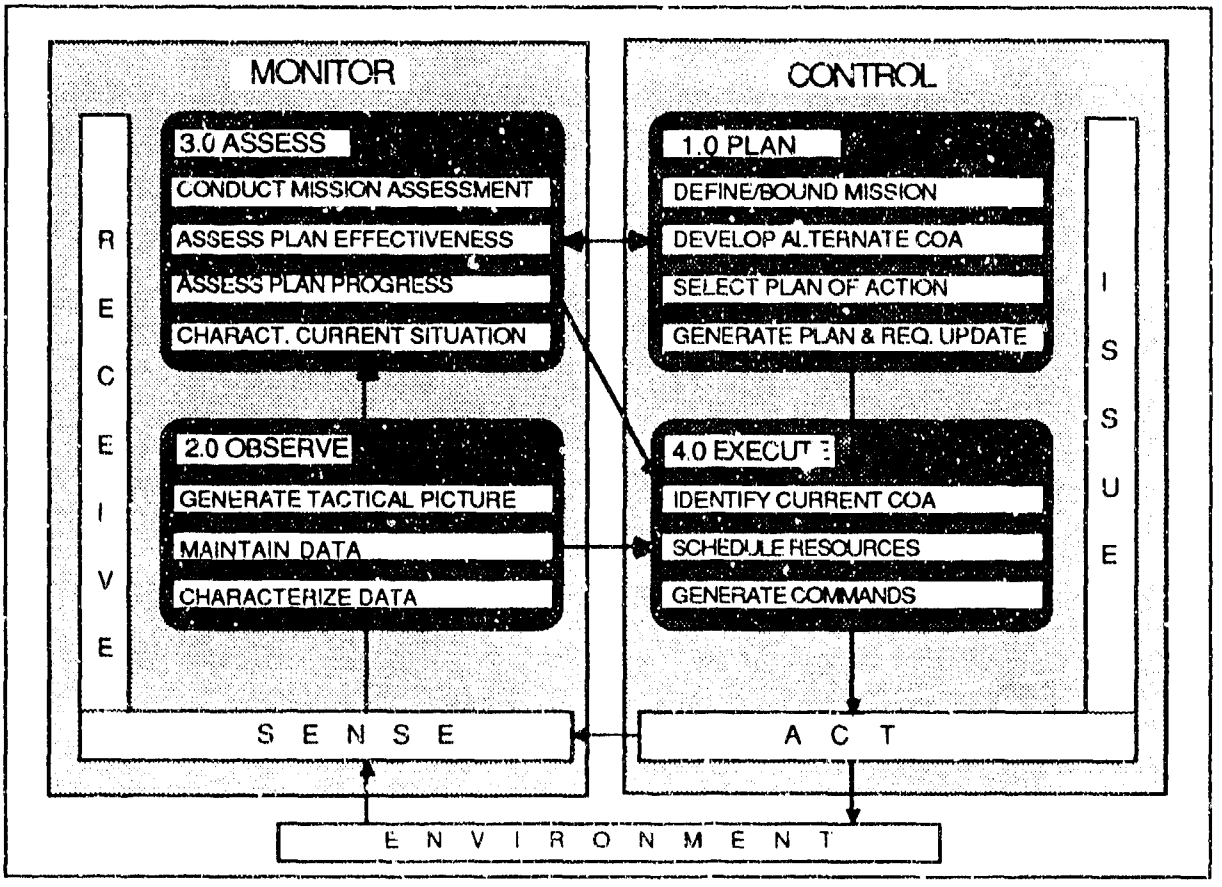

Figure 5. Command Process Model

4.3 PLAN

The Plan function generates optional courses of action intended to achieve the mission. Based on the same kind of assessment that the Assess function produces about projected mission achievement, the Plan function evaluates and selects primary and contingency courses of action, including organizational responsibility, procedures and allocation of resources to general task areas. The criteria for assessing situations and changing procedures are defined by Plan for use in Assess in determining when these conditions exist. The procedures, including rules for allocating resources, are used by Execute to implement the plan and control its progress.

4.4 EXECUTE

The Execute function selects a specific course of action, based on the current assessment of the situation (from Assess). Using procedures established in the plan and data from Observe, specific allocation of resources and tasks or even specific guidance variables are generated as directives and Issued as orders or implemented as Actions. It is the Resource Allocation Directive that represents the product (outcome) of the decision-making process.

4.5 FEATURES OF THE COMMAND PROCESS MODEL

The principal feature to note about the CPM structure is the set of three paths through the decision process. These represent three fundamentally different kinds of decision/control cycles. The outside or largest loop consists of passing through all four functions, while the next loop bypasses the Plan function and the inner loop consists of only parts of the Observe and Execute functions. These loops can be called planning control, mode control, and base control, respectively. The planning loop involves the generation and consideration of multiple courses of action within the Plan function and the selection of a subset of these as a set of contingency plans that can be considered for implementation in the Execution function. Each contingency or branch of a contingency can be considered as a mode of operations that can be activated depending on the situation. The changing of modes is dependent on the assessment of the situation in the Assess function. This dependency is represented by the path from the Assess function to the Execute function in the mode control loop. (This loop is the most important difference from the previous Framework document functions, as will be discussed below.) For a given mode of operation, the base control loop generates directives that are appropriate for that mode, using information from the Observe function.

The separation of the planning control and mode control loops is an important concept in effective decision making. Both Plan and Execute have a role in selecting courses of action. The planning loop involves generation, consideration, and selection of options, but the final decision is deferred until execution. Execute makes that decision, as well as the sequential decisions needed to carry out the selected option. The planning loop is a deliberative one and takes time. Most decisions are made without going through such a process, but rather by choosing among courses of action that are predetermined by prior planning or that are familiar or preferred, due to previous experience (and success). At the same time, the planning loop provides for dealing with the unanticipated situation.

The differentiation of the three loops is an enhancement of the Command Process Model used in the Framework document. As a result, the major functions do not correspond one to one. The sequence of subfunctions in the outer loop of the enhanced CPM, however, is the same as those in the previous Framework model. The grouping is somewhat different and there are two stages of option/course-of-action selection and resource allocation explicit in the new version. Thus there is a basic correspondence of the Observe-Assess-Plan-Execute cycle and the functions of the Framework document: Assemble Information; Assess Situation; Develop/Evaluate Alternatives and Select Course of Action; and Direct Action. This sequence is essentially the same as two other models of the Command Process. Reference (j), an Army source, uses Acquire-Assess-Determine-Direct. Reference (k), providing an Air Force perspective cites the Observe-Orient-Decide-Act loop of Colonel John Boyd. The relation to other models is discussed below.

4.6 RELATION TO OTHER DECISION PROCESS MODELS

The Command Functions listed in the appendix were derived as an amalgamation of several models of decision making. These include the Stimulus-Hypothesis-Option-Response (SHOR) model attributed to the late J. Wohl (reference (l)), the Lawson model (reference (m)) of Sense, Process, Compare, Decide and Act and the Headquarters Effectiveness Assessment Tool (HEAT) model (reference (n)) of Monitor, Understand, Plan, Decide and Direct. Each of these emphasizes a different aspect of the process which the CPM represents. Each has an implicit or explicit Input-Output, Sense-Act or Stimulus-Response functionality to couple the model to the rest of the world. The inputs are data of one form or another, including directives. The outputs can only be data or directives, also, so they can only cause action or possibly other decisions, but they are not the physical action.

4.6.1 Relation to the SHOR Model

The SHOR model (figure 6) emphasizes the Hypothesis-Option decisions as a Yin-Yang of the process. Both involve generation, evaluation and selection (decision) of alternatives; of what to believe or what to do, respectively. These are seen as the processes of dealing with uncertainty of information and uncertainty in outcome. These can also be viewed as interpreting the past (what has been) and predicting the future (what will be), except that option selection initiates a response to "cause" the future and the hypothesis evaluation may involve projections of the current situation.

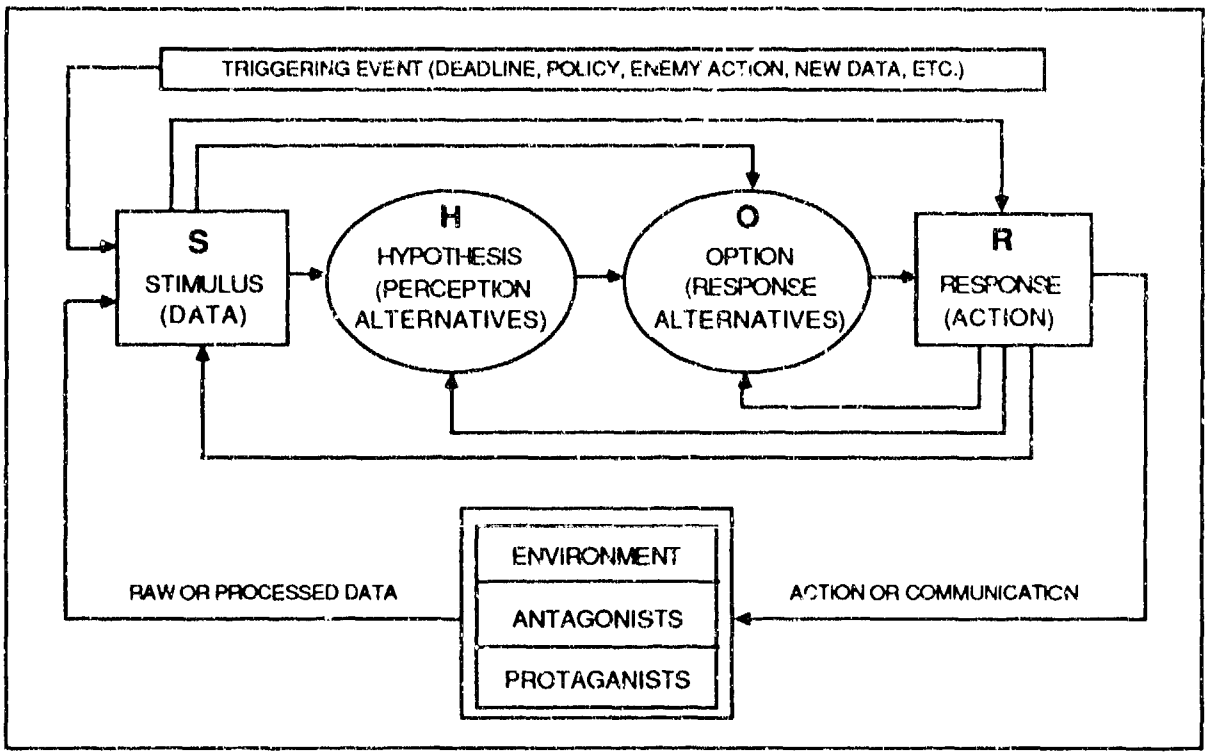

Figure 6. SHOR Model

The CPM recognizes these two halves of the model, putting Observe and Assess under the Hypothesis or Monitor domain and Plan and Execute under the Option or Control side. The reason for the differences is to indicate that there are layers in the decision process.

The Observe function focuses on the data fusion problem of combining "sensory" inputs to form a "perception" of the location and activity of objects in the environment. (The SHOR model put much of the data fusion process in the Stimulus function, but there are hypotheses involved in data fusion, too.) This perception may be colored by expectations arising from knowledge of current plans and activities or of past behavior of the subject elements. It may even be biased by current assessments. The Assess function infers meaning from the observation, including intent. This is a situation assessment and hypotheses involve either current situations or, possibly, they anticipate future outcomes that may occur if events unfold in ways projectable from the current situation.

On the Option side, the Plan function contains the option generation and evaluation processes. The selection of options is a decision that can possibly result in contingency plans that become deferred decisions or preplanned courses of action. The final choice is made in the Execute function, after events have unfolded and/or more information is available to make a better prediction of the

outcome. (The Execute function involves the choice among previously conceived options in order to reflect an aspect of the HEAT model to be discussed below.) The assessment of options requires the same type of process as the situation assessment that projects outcomes as described above. The only difference is that in one case the projection is made with respect to the currently active option, whereas a planning assessment or even a contingency assessment involves the active option and alternative options recently or previously devised. Plan and Execute also have subfunctions to generate the plans and directives that are the products of the process. In the SHOR model, these are both part of the Response function.

4.6.2 Relation to the Lawson Model

The emphasis of the Lawson model (figure 7) is on the comparison of the current (or predicted) state to the Desired State. The model is basically an analogy of a control system. The Sense function takes measurements of the plant (situation) for the control system, while Process involves driving the Plant model with the measurements to determine current state. When there is no difference between the current state and the desired state, no change in control is needed. When there is a difference, the controller "Decides" what control signal to send (Act) to the plant to cause it to converge on the desired state.

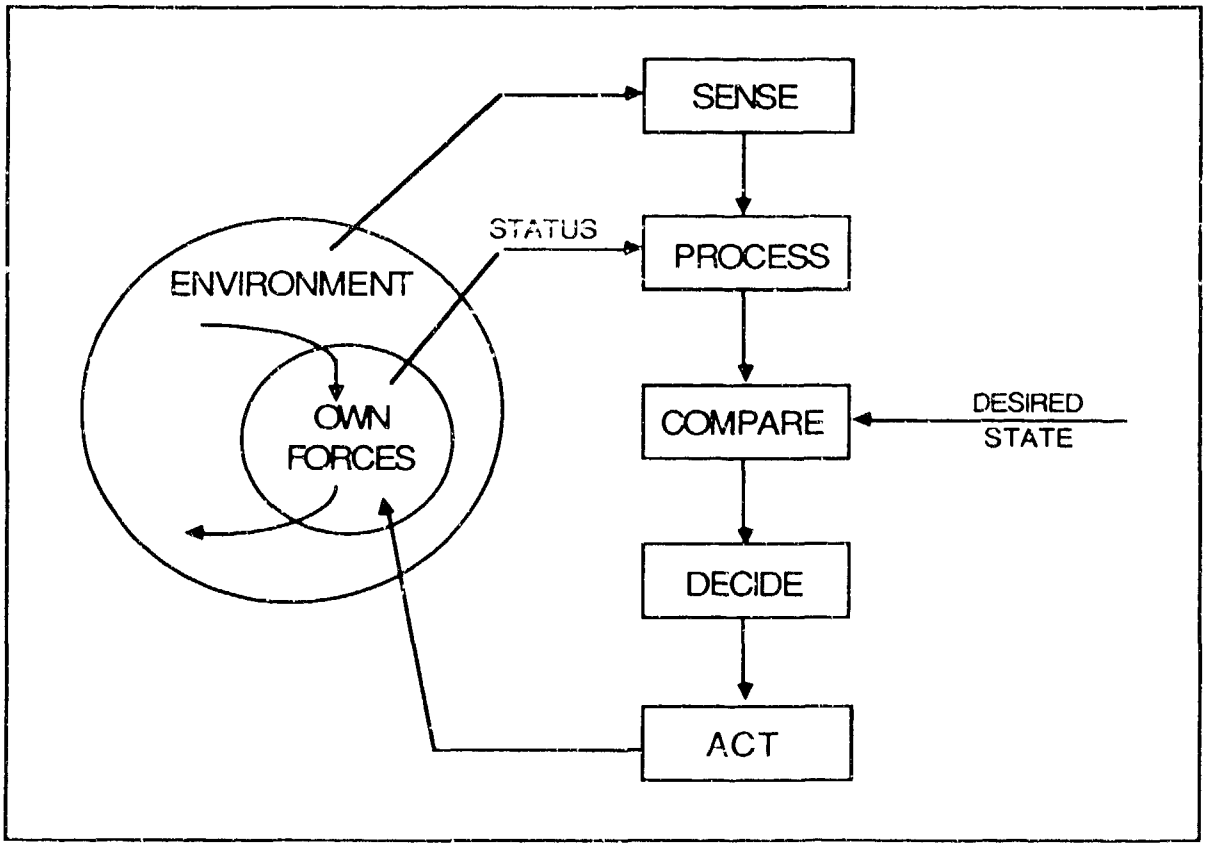

Figure 7. Lawson Decision Process Model

Figure 8, shows a Modified Lawson model based on the CPM functions. The Process function is replaced by Observe. The concept of Compare is implicit in the Assess function. The Desired State comes from some "higher level" in the Lawson model, but the Plan function generates it in the CPM based on plans and directives from the higher levels. The active option is the basis for comparison for current control activity. The Plan function also lays out how to execute the control. The Plan function, in addition, generates several possible states for comparison, any of which can be the basis for control changes, depending on the situation. Then the comparison is done relative to the various desired states and may cause a change in control mode within Execute, which replaces Decide.

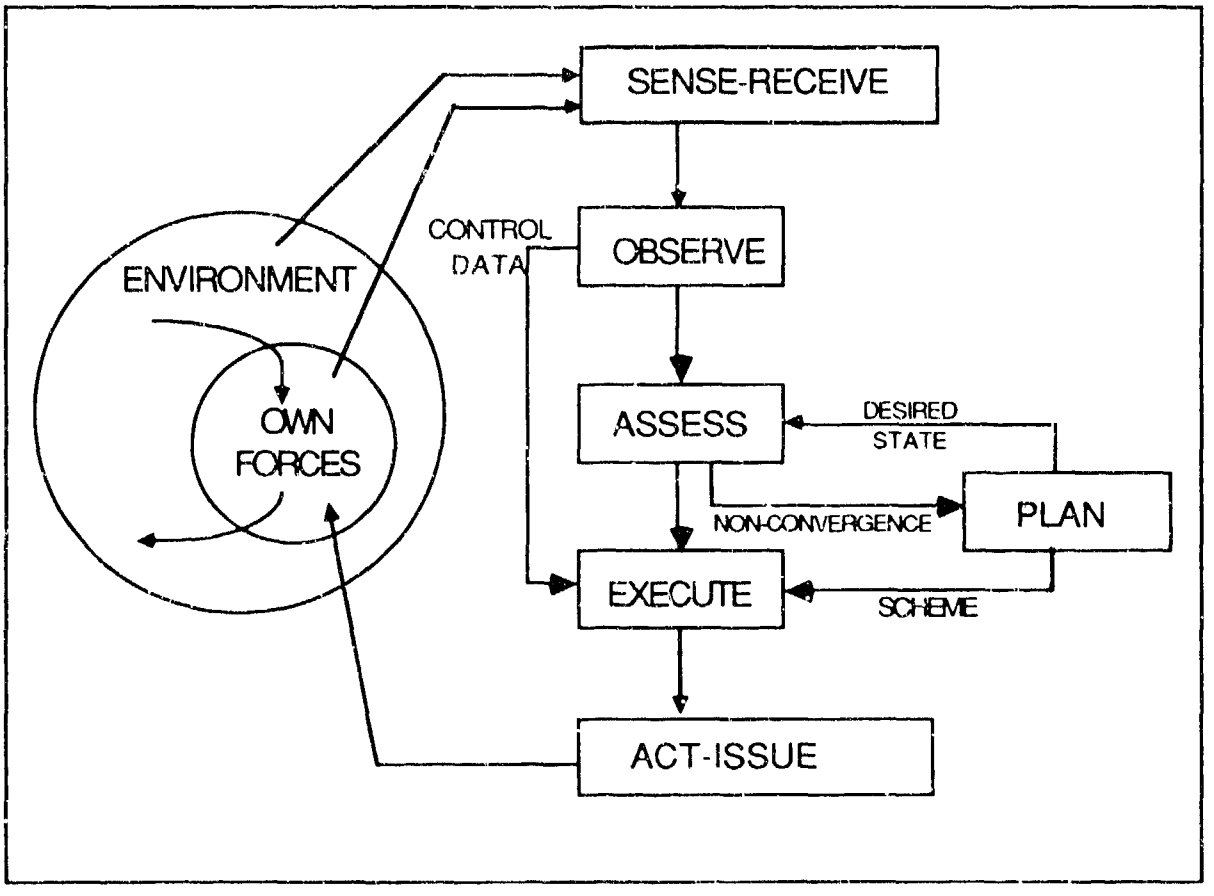

Figure 8. Modified Lawson Model

4.6.3 Relation to the HEAT Model

The HEAT model (figure 9) emphasizes the role of planning in the decision process. The original model had all planning processes, including option generation, prediction and decision, as part of every decision cycle. In addition, lower level direction activity occurred in a simple stimulus-response loop. Later, it was realized that good planning provided a short circuit, such that, if situations had been anticipated and preplanned contingency options generated, predetermined decisions could be implemented more quickly and with less confusion. This results in three loops in the process that represent three modes of decision making adopted in the CPM. This is the reason for the role played by the Assess function in determining when to invoke each of the three loops.

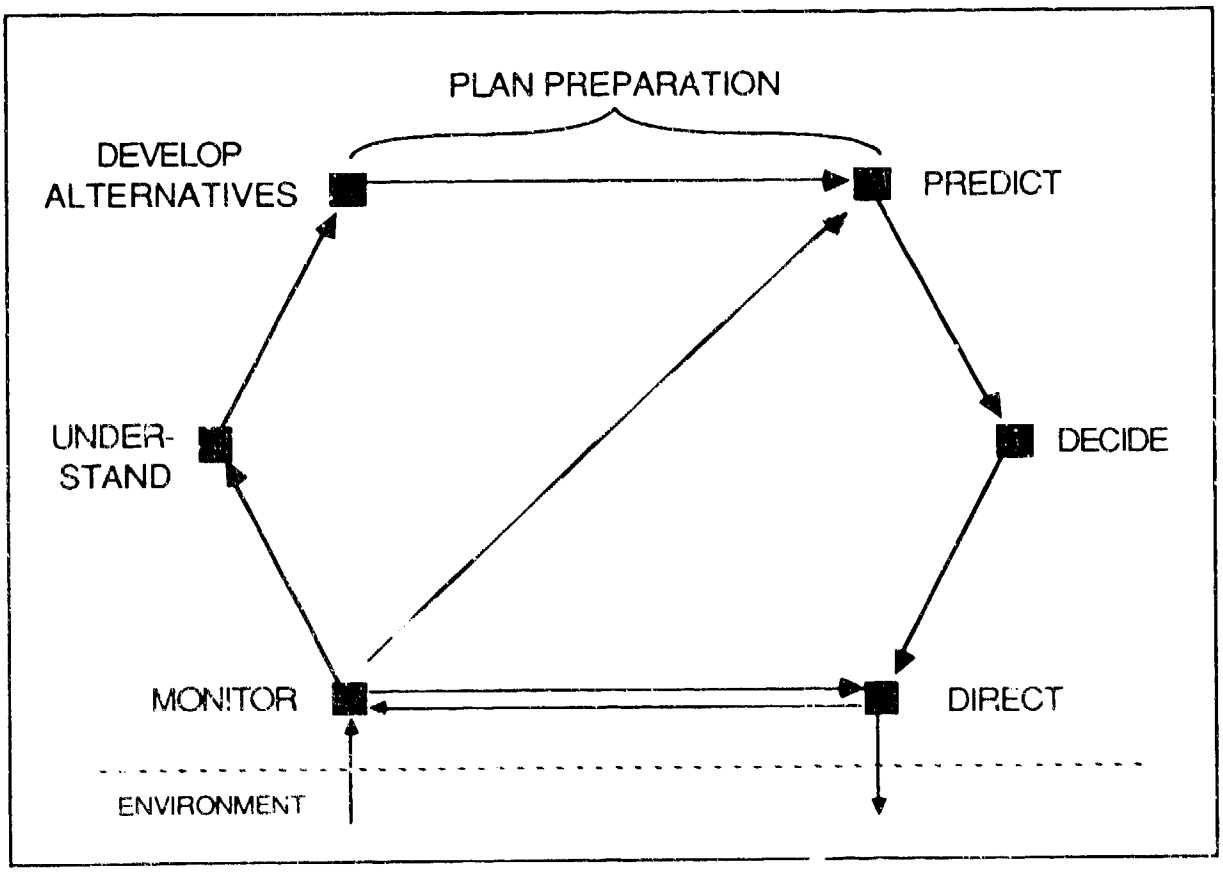

Figure 9. HEAT Model

4.7 IMPLICATIONS OF COMMAND PROCESS MODEL

The Command Process Model is intended to provide an organized set of functions that can be used as a structure to define internal and external outcomes of the decision process. It is also intended to provide insight into important considerations for understanding of the decision process. This, too, will aid in the definition of outcomes.

The outcomes of the decision process, i.e., decisions, are the information state results or events of the General Process Model in figure 2. Several kinds of decisions are involved in the decision process. Some of these will be the kind of decision that causes physical state changes or emissions, through Act and Issue. Some of them will cause changes in other information states, i.e., other decisions. These occur throughout the Command Process Model.

4.7.1 Two Kinds of Decision Making

There are two kinds of decisions that are made within the decision process: intentional and inferential. The main purpose of decision making is to initiate a function that is intended to cause a change of state or an emission, which, in turn, is intended to have further effects, internally or externally. This is an "intentional" decision. But, in reaching those decisions, it is often necessary to infer, from available information, the nature of the stimuli or states of the system and its surroundings, including other systems. These are "inferential" decisions. In general, the difference is that the former is a "decision to do something" and the latter is a "decision that something is true or false" or a "decision to believe something". Intentional decisions involve resource allocation and direction; while inferential decisions concern data interpretation and situation assessment. Inferential decisions are made in Observe and Assess, while intentional decisions are made in Plan and Execute. These two kinds of decisions are synonymous with hypothesis selection and option selection. These represent the two sides of the model: the inferential side which monitors and the intentional side which controls.

In the base control loop, inferences are made in Observe relative to the tactical picture or force readiness, while Execute makes intentional decisions regarding resource-task allocations and direction.

In the mode control loop, Assess makes inferential decisions about the situation to which Execute responds with an intent to change operations.

In the planning loop, these two kinds of decisions are performed at a higher level. The Assess function infers that current trends are not converging and Plan generates a new course of action intended to correct the problem.

4.7.2 Information Flow and Control Flow

The two kinds of decisions correspond, roughly, with two kinds of data flow: Information Flow and Control Flow. Information is essentially what can be inferred from data. Control is a form of data that results from intentional decisions. Since inferences are made in Observe and Assess, two kinds of information can be identified as simply observations and assessments. On the control side, there are plans and directives. The differences are subtle and only important in a relative way. Organizational relationships determine how information and control are used in a system.

4.7.3 Authority/Responsibility

It is well known that authority can be delegated but responsibility can not. A Commander is responsible for the actions of subordinates, so he can delegate the authority to make the decisions to perform them. While the lack of authority does not prevent action, it inhibits it in a well-disciplined organization, while having authority enables decision-making action. It is important to have the right amount of authority delegated to the right level at the appropriate time. With respect to the Command Functions, responsibility and authority are characteristics of control, involving Plan and Execute. In particular, authority is a condition for making intentional decisions, though not always required.

4.7.4 Coordination

Coordination among organizational elements is not a separate function, but involves performing the decision process functions as a joint effort. In effect, coordination is a multi-element planning, decision or synchronization activity. It is accomplished by performing the decision process individually, sharing results, identifying conflicts or mutual support requirements, and revising plans to make them consistent. Synchronization is done by using times, events or signals to initiate action. Each of these steps is individually contained in the Command Functions.

4.7.5 Cost of Change

An important factor must be taken into consideration when making a change in control mode or changing plans; that is the cost of change (reference (o)), which is the time to implement the change and the possibility that the time or the change itself will cause additional losses due to delay or confusion. This factor must be considered in the assessment of the situation and the replanning or mode control cycles. Another important point is that this factor is mitigated by good contingency planning and highlights the value of such planning. Having prepared for contingencies reduces the time needed to implement them and reduces the chance of confusion, if they are simply stated and familiar to the organizational elements.

4.8 SUMMARY OF COMMAND FUNCTIONS

The Command Functions, as defined in the enhanced Command Process Model, emphasize the following crucial ideas.

a. Planning is an essential function even during the Execution phase, where it is often called Replanning.

b. There are two sides to the decision process, interpretation and direction, inferential and intentional, monitor and control, etc.

c. These two sides can have many layers, but for simplicity, three conceptual layers of decision activity are descriptive of three classes of decision cycles, base control, mode control and planning control.

d. The purpose of the decision process is the allocation of resources to perform certain functions in order to achieve an intended outcome.

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APPENDIX A

COMMAND FUNCTIONS

Appendix A. COMMAND FUNCTIONS

INTRODUCTION

The Command Functions, defined in this appendix, are the result of an evolution and merging of the functions of the Command Process Model (CPM), described in the Command, Control, Communications and Intelligence Operational Requirements Framework document of July, 1988, and the Command Functions defined in the Carrier Battle Force (CVBF) Command and Control and Communications Current Architecture description of August 1988. There was little difference between them and the modifications to the CPM are noted below. A summary of these functions and a discussion of their interpretation is provided in the main report.

ORGANIZATION OF THE APPENDIX

The principal Command Functions are Plan, Observe, Assess, and Execute. Each of these is described in its own section, numbered in that order. Within each of these sections, there are two subsections (the first and last in each section) called Receive and Issue; these are labeled with the section number and an "R" or "I", respectively. These subsections represent the data that has to be transferred between and among the Command Functions and/or the external world. Collectively, they represent all the data transferred, but they are listed with the Command Function that uses or produces them.

The additional functions of Sense (S.0) and Act (A.0) are added to account for coupling to the physical world, whereas Receive and Issue are connections to the information world. The letter designations were chosen so that no sequence would be implied relative to the four principal functions.

Preceding the functional descriptions is a list of all the functions to the third tier of decomposition. This list provides a compact view of the structure of each function, as well as serving as a table of contents.

DIFFERENCES FROM THE FRAMEWORK DOCUMENT

The previous Command Process Model presented a decision cycle in the natural order from the input to the output. The enhanced version puts emphasis on the three cycles of decision making as described in the main document. Because the behavior of the model, with respect to these three cycles, depends on the procedures prescribed by the plan, the order of the functions has been changed to start with Plan, then to follow the middle cycle of Observe-Assess-Execute.

The names used for the four principal functions have been shortened to one word for convenience. They correspond, roughly, to the longer phrases of the previous version, as follows.

Observe	Assemble Information
Assess	Assess Situation
Plan	Generate/Select Course-of Action
Execute	Direct Actions

There is a slight difference, however, in the decomposition/allocation of the subfunctions of the third and fourth functions in the above list, in order to account for the contingency branching process in the middle cycle. Table A-1, Correspondence Between Functions, shows where the split was implemented. Note where the old 2.2 and 3.4 were divided.

TABLE A-1. CORRESPONDENCE BETWEEN FUNCTIONS

Current Function Number and Name		Previous Number
2.0	OBSERVE	
2.1	CHARACTERIZE DATA	1.2
2.2	MAINTAIN DATA	1.1
2.3	GENERATE TACTICAL PICTURE	1.3
3.0	ASSESS	
3.1	CHARACTERIZE CURRENT SITUATION	2.1
3.2	ASSESS PLAN PROGRESS	Part of 2.2
3.3	ASSESS PLAN EFFECTIVENESS	Part of 2.2
3.4	CONDUCT MISSION ASSESSMENT	2.3
1.0	PLAN	
1.1	DEFINE AND BOUND ASSIGNED MISSION	3.1
1.2	DEVELOP ALTERNATIVE COURSES OF ACTION (COA)	3.2
1.3	SELECT PROSPECTIVE COURSES OF ACTION	3.3 & Part of 3.4
1.4	GENERATE PLANS AND UPDATES	Part of 3.4
4.0	EXECUTE	
4.1	IDENTIFY CURRENT COURSE OF ACTION	Part of 3.4
4.2	SCHEDULE RESOURCES	3.5
4.3	GENERATE COMMANDS	4.1

Figure A-1, Command Process Model Vs. Previous Version, shows the Command Functions to the second tier of decomposition, as in figure 5. In addition, a frame has been inserted to surround those functions that were contained in the function, "Develop/Evaluate Alternatives and Select Course of Action", in the previous version. This frame corresponds to Previous Numbers 3.1 to 3.5 in Table A-1.

The function, Plan, has been numbered 1.0 in the new version in order to emphasize its role in establishing the procedures to be used in the other functions.

As noted above, the functions of Sense and Act were added explicitly in this version.

An addition to these changes, there were minor changes in function 2.2.3, to highlight assimilation of own resource data, and the subfunction 1.2.5 was added to recognize the dependence on external support. Function 1.2.4 is a combination of the previous 3.2.4 and 3.2.5, since activity and procedures are closely related.

REVISION OF JANUARY 17, 1990

The revision of January 17, 1990, corrected errors in Table A-2 and reversed functions 2.1 and 2.2.

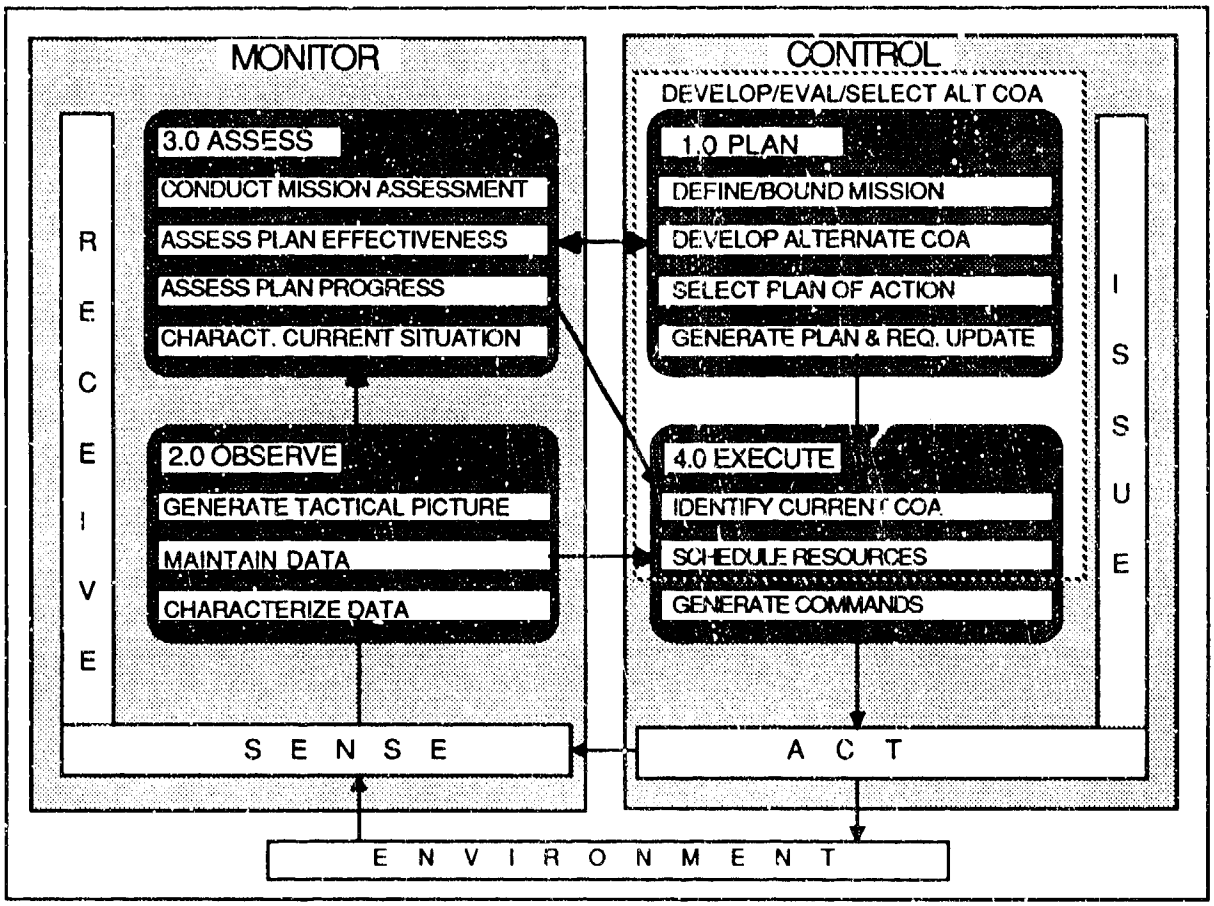

Figure A-1. Command Process Model Vs. Previous Version

TABLE A-2. LIST OF COMMAND FUNCTIONS

TABLE A-2. LIST OF COMMAND FUNCTIONS (Continued)

TABLE A-2. LIST OF COMMAND FUNCTIONS (Continued)

TABLE A-2. LIST OF COMMAND FUNCTIONS (Continued)

TABLE A-2. LIST OF COMMAND FUNCTIONS (Continued)

1.0 PLAN

"Planning" is the establishment of control procedures for the accomplishment of a purpose. It generates the pattern for the desired behavior of the forces or elements to be controlled in response to future events caused by one's own or others' actions. Several alternatives may be developed but only one chosen as the Plan of Action, although it may have contingency branches which anticipate uncertainty in multiple future events.

At a given organizational level, this function provides for the reception of direction from a higher organizational level, bounds the problem (1.1), generates alternative courses of action (1.2), provides for the selection of a plan consisting of a primary and contingency courses of action (1.3), and then generates the initial plan, and any required updates to it (1.4), for implementation by other functions. Any of the subfunctions of PLAN may uncover ambiguities or conflicts in direction or shortfalls in resources. These are referred to higher authority for resolution.

The objective of this function is to establish a plan or framework of contingencies with control procedures and a set of rules to resolve conflicts caused by limitations and uncertainties. It is through the ASSESS (3.0) function that evaluations/assessments of alternative plans are performed, based on the proposed use of available resources. The PLAN (1.0) function selects particular options and establishes control procedure which are used to resolve conflicts. The selection of the preferred option and control procedures is intended to provide a structure for the desired behavior of the resources available to a given organizational unit. Limitations in the resources and uncertainties in the exact knowledge of the problem to be solved require the capability to handle various types of iterations, prioritizations and plan updates such that the overall goals are met when it may not be possible to follow an exact preconceived solution/plan. The main product of the PLAN (1.0) function is a plan of action, which is a clear and unambiguous set of tasks and procedures that the EXECUTE (4.0) function receives for implementation as guided by information from OBSERVE (2.0) and assessments from ASSESS (3.0). Plans are disseminated externally and, in particular, to subordinates, for guidance, and to other organizations for coordination.

1.R RECEIVE DATA

1.R.1 External

Directives from higher organization level and coordinating information from other resources that define objectives, bounds, limits, doctrine and assumptions.

1.R.2 From ASSESS (3.0)

Current tactical situation and assessment/ evaluations of contingencies, associated risks, and resource readiness/availability for plan selection/generation.

1.1 DEFINE AND BOUND ASSIGNED MISSION

This function is the first step in the planning process. It is this process that bounds the problem to be solved and limits the options for consideration. It interprets the directive from higher authority within the framework of the general background of the operation, the superior's mission and the capabilities and limitations of assigned resources. It establishes specific goals and objectives and characterizes the generally expected unfolding of the situation. It is constrained by established

procedures and rules of engagement set by higher authority. Enemy force characteristics are described and his response to own force our mission is postulated.

1.1.1 Interpret Mission/Directives from Higher Authority

1.1.2 Develop Mission Statement

1.1.3 Describe Area of Operations

1.1.4 Describe Own and Related Force*

1.1.5 Describe Enemy Force

1.1.6 Estimate Relative Strengths and Weaknesses of Opposing Forces

1.1.7 Postulate Enemy Courses of Action

1.2 DEVELOP ALTERNATIVE COURSES OF ACTION (COA)

"Develop Alternative Courses of Action" uses the characterization of the current situation (Cf. NWP-11, Estimate of the Situation) developed in 3.1 along with the Mission Definition derived in 1.1 to conceive proposed courses of action and alternatives (Options). In this process, additional information or guidance may be requested form the higher command authority, when proposed options appear to go beyond the bounds set above.

This process involves the delineation of procedures and nominal identification of organic and non-organic resource requirements for each proposed option. Within each option, a more specific characterization of the expected situation is derived in terms of the proposed activity, operating procedures and enemy responses anticipated for that approach. Within each option, several contingencies may be executable in 4.0, while carrying out the plan. These contingencies of the plan are an integral part of each option, along with the conditions which, when met, would indicate which contingency to execute.

For each option, an evaluation of the potential outcome, based upon an identified effectiveness criteria, risks and benefits will be required. This kind of assessment is performed in the ASSESS (3.0) process.

In the event of the necessity to perform a replanning process, new alternatives may need to be generated or earlier options updated with more recent information or direction.

1.2.1 Propose Organizational/Command Structure

1.2.2 Propose Mission/Task Objectives for Subordinates

1.2.3 Propose Resource Composition

Based upon the required supporting tasks and the availability of resources, propose the composition of resources.

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* Allied, Joint, other U.S. Navy

1.2.4 Propose Resource Activity (Time, Place, Tactics) and Propose Operating Procedures

Propose standard operating procedures, tactics and rules of engagement for each course of action.

1.2.5 Determine Requirements for External Support

1.2.6 Propose Enemy Responses within each COA

1.2.7 Identify Effectiveness Criteria for Each COA

1.2.8 Relate Effectiveness Criteria to Mission Success Criteria

1.3 SELECT PROSPECTIVE COURSES OF ACTION

This is the classical decision function. "Select Plan of Action" provides a quantitative or qualitative prioritization or preference among the alternatives. This process involves a review of the assessment and potential outcome of each alternative and its advantages/disadvantages, suitability, feasibility, and acceptability; and the estimation of the probability of success and the risks associated with each alternative. The assessment relies on the capabilities available in 3.3. In this function, additional information or resources can be requested from a higher organizational level if the proposed plan has an unacceptable risk. This function provides for the selection of a set of tasks to be implemented and its corresponding set of control procedures. The set of tasks and the control procedures constitute the elements of the plan, which embodies the strategy/approach and associated contingencies or branches.

This function also must accommodate the replanning/update process when it is determined in ASSESS (3.0) that the latest plan can no longer be met (see 3.3). This may require cessation of tasks being executed. As a result of replanning, the new set of control procedures and tasks becomes the latest plan and replaces the previous one. Minor adjustments in the plan might be accommodated in the plan generation process (1.4).

1.3.1 Evaluate Own-Courses of Action with Respect to Suitability, Feasibility, Acceptability

1.3.2 Evaluate Effectiveness of Own-Courses of Action Against Enemy COA

1.3.3 Prioritize Alternative Courses of Action

1.3.4 Identify Risks and Shortfalls

1.3.5 Select Primary and Contingency Courses of Action

1.4 GENERATE PLANS AND UPDATES

The generation of the original plan and associated updates involves the elaboration of the detail required to clearly and concisely communicate the expected objectives, schedule of events and methods of achieving them to other elements of the organization including subordinates, support elements and superiors. This plan/update includes such items as the intended movement, support, protection, coordination, and methods of control of the assigned resources.

The plan must also identify a set of conditions that describe the expected situation, and the criteria for identifying those situations, which will call for a change in the course of action in effect at that time. These criteria are used by ASSESS (3.0) to identify plan progress and for the interpretation

of the meaning and intent of the future situation. The conditions must be distinct and separable (mutually exclusive) in order to avoid confusion in the execution of the plan. The actions must also be mutually exclusive in a way that will not cause resource conflict. If the conditions or actions are ambiguous, replanning will be required.

The formulation of the plan may involve the dissemination of a preliminary operational plan/directive to subordinates. After coordinating with subordinates and evaluation the asset readiness posture, the final plan is generated for dissemination to higher authority, coordination elements and to subordinates.

1.4.1 Develop Concept of Operations

1.4.2 Elaborate the Objectives, Organization, Resources and Procedures for Each Contingency.

1.4.3 Specify/Modify Contingency Situations and Responses.

1.4.4 Delegate Authority in Accordance with Plan

1.4.5 Document Plan and Supporting Annexes

1.I ISSUE OPTIONS, PLANS, UPDATES

1.I.1 External Promulgation of Plan

Plans and reports to subordinate organizations for guidance and to others for coordination. Reports of inadequate guidance and resource shortfalls to higher level authority.

1.I.2 External Request for Authority

Request for authority to cover a situation if not authorized in plan.

1.I.3 To EXECUTE (4.0)

Plan of Action and Updates for implementation by own organization.

1.I.4 To ASSESS (3.0)

Plans for assessment of bounds, evaluation of options and criteria for plan progress assessment.

1.I.5 To OBSERVE (2.0)

Plans for archival purposes and criteria for recognition of the present situation.

2.0 OBSERVE

This function provides for the collective perception of the current and projected tactical picture as a result of the combination of all available information. It supports the assessment in 3.0 of the current situation such as threat posture, hostile activities and encounters. It depicts own force posture and maintains own force operational data. The function associates and correlates the pre-processed sensor reports from own and other resources into a multi-source event description that includes event position, time, confidence, and other properties. It discriminates objects and events according to types and tracks objects. The function also addresses the state of own force and the environment by combining relevant data about them.

At a given organizational level, this function provides for the reception of information from within the organization for the purposes of characterizing the incoming data (2.1) including the current direction from EXECUTE (3.0), maintaining/updating a master set of information (2.2) and generating the current and projected tactical picture (2.3) to be provided to the ASSESS (3.0) and EXECUTE (3.0) functions. This evaluation process generates the best level of knowledge concerning all observed contacts (hostile, friendly, neutral or unknown and the background).

Several hypotheses about the current tactical picture may be postulated. Evidence in support or denial of these alternative pictures is sought in the event data from information sources. Each hypothetical picture may exist with varying degrees of confidence. The most important hypotheses may be the most likely or the ones of most concern. All important hypotheses must be available to the ASSESS (3.0) function.

From all the estimates and confidence levels, the current tactical picture is generated and is used in the ASSESS (3.0) function. It is through the positional/motion estimates, with associated confidence levels, that the EXECUTE (4.0) function obtains information to generate the commands required.

2.R RECEIVE DATA

2.R.1 External Receive Communications Data

Raw and preprocessed sensor data and correlated or associated data from own and other sources for information sharing. Resource Status and Material Condition data from own sources.

2.R.2 External Sensor/Event Data

Sensory/event/resource data for combination with other data and archiving.

2.R.3 From EXECUTE (4.0)

Command data defining status of execution and resource allocations for purpose or anticipating events as well as for archiving status of execution.

2.R.4 From PLAN (1.0)

Plans, doctrine, and data concerning higher organizational levels/resources for archival criteria for recognition of the situation.

2.R.5 From ASSESS (3.0)

Control of tactical picture projection and mission assessment for archiving.

2.R.6 From SENSE (S.0)

Sen ory/Event Data

2.R.7 From ACT (A.0)

Data for Command Feedback

2.1 CHARACTERIZE DATA

All available data required for the assessment of the situation is assembled in this function. After sorting and associating all source event data (2.1.1) into groups with similar attributes the data is further processed, or correlated, (2.1.2) to identify known objects and aid in the discrimination of objects and events with measures of confidence. Resource Status/Condition data are sorted and compiled (2.1.3) in preparation for assessment.

2.1.1 Sort and Associate Events

This function sorts and associates individual detection events into data groups having similar attributes. Based on these data and known properties of object types, this function produces a report which includes a group of measurements, time of occurrence, and other properties detectable by the sensor along with confidence levels.

2.1.2 Discriminate and Identify Events

This function compares the information reports with known properties of object types to produce a preliminary discrimination between events and objects, and among object types. A full discriminatio ay be deferred until reports from all available sensors are correlated in function 2.3.1. This preliminary discrimination takes the form of an event/object identification and confidence level.

2.1.3 Compile Resource Status/Condition Data

This function is the collection and analysis of statistics concerning the status/condition of all available resources including own status/condition. This function monitors the configuration and readiness of resources (equipment, weapons, personnel, etc.) and collects information so that required actions can be directed and performed within the limits of capabilities, and so corrective actions can be taken to overcome degradations or to reconfigure resources.

Knowledge of the status of resources to conduct the mission is compiled, ambiguities are resolved and a report is generated for use in the assessment of plan progress and effectiveness. Personnel and material status is compiled for own and supporting resources. Material status includes platform, equipment and expendable stores.

2.2 MAINTAIN DATA

This function receives sensory and message data/information and maintains the historical and real-time/near real-time tactical data information bases. Tests are conducted to ensure that the consistency of the data is maintained.

2.2.1 Update
2.2.2 Archive
2.2.3 Test

2.3 GENERATE TACTICAL PICTURE

The current tactical situation is determined by integrating the position and movement of own force and enemy units from all-source sensor information. The tactical picture is composed of the position, velocity, identity, status, and salient characteristics of all objects in the area of interest along with estimates of the quality of those parameters. It also may project the tactical picture into the future based on direct sensing data and the requirements defined by the Assessment of Plan Progress (3.2). The location of tactically significant oceanic (e.g., fronts and eddies), electromagnetic (e.g., ionospheric) and acoustic (e.g., sonic layer depth) features are included, as are the current and forecast weather conditions.

It is this function that takes all the observed contacts, associated relationships, and attributes and generates the best level of knowledge concerning all contacts (hostile, friendly, neutral or unknown. The level of knowledge achievable is dependent on the data fidelity and sensors/processing available. The goal is to resolve positional estimates, motion estimates, (velocity, direction, acceleration) and associated attributes such as actual/estimated type. All estimates are provided with some confidence level. Multiple hypotheses may be carried awaiting sufficient event data to clarify differences. Additionally, the best knowledge of the environmental effects is generated.

In specific cases, this current tactical picture can provide the required data to perform branch selection in EXECUTE (4.0) for certain types of response criteria. Additionally, certain elements of the tactical picture are compared to the desired result in EXECUTE (4.0) for actual command generation for the accomplishment of specific tasks by specific resources.

In addition to the environmental background, the position of objects/events relative to some artificial boundaries (such as search areas, missile envelopes, etc.) may be important. These artificial boundaries are elements of the tactical overlay picture.

2.3.1. Develop Current and Projected Contact Picture

Development of the current and projected contact picture involves the quantification of positional/motion estimates and confidence levels, the correlation and the classification based upon associated attribute and confidence levels of all contacts and own forces.

2.3.2 Develop Current and Projected Geophysical/Environmental Picture

2.3.3 Develop Current and Projected Significant Tactical Information

2.I ISSUE REPORTS AND DATA

2.I.1 External

Data for information sharing by other organizational elements

2.I.2 To EXECUTE (4.0)

Data for the purpose of command generation (4.3.2) and branch selection (4.1.1).

2.I.3 To ASSESS (3.0)

Current and projected tactical picture, readiness status, current COA and COA option to assess the progress and effectiveness of the plan.

3.0 ASSESS

The ASSESS function derives meaning from the information provided by OBSERVE (2.0) in the context of the mission and the plan prescribed by PLAN (1.0). It may also receive assessments from other organizational elements and share its assessments with others. Assessment of mission performance requires a characterization of the current situation (3.1) involving own and enemy posture, neutral activity, projected tactical picture and environmental effects. The assessments of plan progress (3.2) and of plan effectiveness (3.3) support planning, control and execution. Mission assessments (4.4) provide feedback to higher authority once a mission has been completed or aborted or status of the mission while in progress.

Assessment of plan progress (3.2) compares the current situation to the criteria for selecting contingencies or particular action sequences in order to support the branching function in EXECUTE (4.0). Assessment of plan effectiveness (3.3) provides direction and control to the PLAN (1.0) and EXECUTE (4.0) function by indicating whether the current action is meeting the existing plan or a new plan or update is required. Assessments of various options (during planning or significant replanning) are essentially assessments of plan effectiveness done for notional plans instead of the one being executed. The nature of the assessments of plan progress, plan effectiveness or option effectiveness vary in terms of fidelity and/or speed, whether performed in advance or during execution.

An assessment of mission performance provides an assessment of the plans, actions and results of operations conducted to accomplish the mission. In the case of an aborted mission, the analysis examines the progress made in accomplishing the mission and the conditions that caused the mission to be aborted. During the operation, these constitute progress reports to higher authority detailing assessments of force performance, current hostile threat, neutral activity and current force assets status. Conflicts may be resolved by requesting additional information from higher organizational levels or reference to PLAN (1.0).

3.R RECEIVE DATA

3.R.1 External

Assessments from Others.

3.R.2 From PLAN (1.0)

Proposed Goals for Bounding, Proposed Options/Procedures for Alternative Selection and Conflict Resolution; Criteria for Plan Progress Assessment.

3.R.3 From OBSERVE (2.0)

Current Tactical Picture and Resource Status and Current COA.

3.R.4 From EXECUTE (4.0)

Current branch for interpretation of tactical picture.

3.1 CHARACTERIZE CURRENT SITUATION

Based on the objective (non-subjective) information from OBSERVE (2.0), this function attempts to extract the meaning or implication of the current tactical picture in terms of capabilities, advantages and intentions. This characterization is used by other functions of ASSESS. Several hypotheses about the situation may be generated. Evidence in support or denial of these possible meanings is sought in the data from OBSERVE (2.0). Each hypothesis may exist with varying degrees of confidence, risk and payoff.

Certain aspects of the information may have particular importance in carrying out an assessment. These may be highlighted in order to provide for more efficient or responsive assessments.

3.1.1 Characterize Enemy Posture

A characterization of the enemy's posture involves an evaluation of tactics and operational effectiveness, the state of operational capability and readiness, intentions, and the vulnerabilities.

3.1.2 Characterize Own-Force Posture

A characterization of the own force posture involves an evaluation of tactics and operational effectiveness, the state of operational capability and readiness, intentions, and the vulnerabilities.

3.1.3 Characterize Neutral Activity

3.1.4 Characterize Environmental Effects

A characterization of the environmental effects involves an interpretation of the atmospheric, geophysical and oceanographic effects as it relates to the situation.

3.1.5 Highlight Significant Tactical Information

Highlighting of significant information is the additional analysis performed to compare postures, identify outside influences and identify advantages and weaknesses of the situation.

3.2 ASSESS PLAN PROGRESS

This function evaluates progress along the plan in order to support the decision to EXECUTE (4.0) by comparing the known current situation (including hostile intent) with a set of conditions used to determine if the plan is being executed toward the expected sequence of events or intended outcome. These criteria are established by the PLAN (1.0) function. As long as the plan is being met (see 3.3), then this function defines the continuation process including some required branching decisions.

3.2.1 Compare Current or Projected Tactical Situation to Plan

3.2.2 Determine if Contingency Criteria Met

3.3 ASSESS PLAN EFFECTIVENESS

In support of the PLAN (1.0) function, the effectiveness assessment is used to assess bounds, develop options, and provide conflict resolution and identify risks in the current plan. The assessment may result in the realization that the current plan (including its contingencies) is not adequate to accomplish the mission and that a new plan or strategy is required. If a new update is required then the execution process may be inhibited and a new replan is initiated.

This function provides the anticipation necessary to avoid blindly following a plan that is no longer likely to succeed, due to changes in the intermediate outcomes or previously unknown information or altered assumptions. This function projects the current situation based on expected results of one's actions and inferences derived from knowledge about enemy and own force posture, capabilities, and intent. This projection results in an anticipated outcome and is couched in terms of its likelihood of occurrence and associated risks and payoffs.

When ASSESS needs to conjecture future situations, it will advise OBSERVE what assumptions to make in order to predict the future tactical picture, if they are different from what are substantiated by the state vectors derived from the data.

As an assessment of the latest (current) plan, deleterious outcomes indicate the need to replan. As an assessment of options during the planning (or replanning) process, this evaluation can serve as the means, in PLAN (1.0), to rank or prioritize the options under consideration.

3.3.1 Identify Uncertainties or Deviations from Plan

3.3.2 Determine Adequacy of Resources and Data

3.3.3 Predict Outcome and Likelihood

3.3.4 Compare to Desired Outcome

3.3.5 Identify Replanning or Update Requirements

3.3.6 Evaluate Relative Merits or Options

3.4 CONDUCT MISSION ASSESSMENT

When the mission or an intermediate objective has been accomplished, suspended, or aborted, mission assessment is performed. This involves an assessment of goals and objectives that were met, reconstruction of events and lessons learned that may be of value in future missions or engagements. During the operation, this constitutes a progress report to higher authority.

3.4.1 Conduct On-Going/Intermediate Assessments

3.4.2 Conduct Post Operations Reconstruction/Final Assessment

3.I ISSUE REPORTS AND ASSESSMENTS

3.I.1 To External for Status of Operations and Mission Assessment

Reports and assessment data to other organizational levels for the purpose of sharing assessment information or gaining additional information for conflict resolutions.

3.I.2 To PLAN (1.0)

Assessment/evaluation of plans for the purpose of bounding, developing options/control procedures, providing conflict resolution and supporting updates.

3.I.3 To OBSERVE (2.0)

Assessment of plans for archiving.

3.I.4 To EXECUTE (4.0)

Assessment of plans for the purpose of continuing execution, selecting the next branch, or inhibiting executions during an update process.

4.0 EXECUTE

The EXECUTE function provides the processes that define and describe the specific actions to be effected in order to "carry out" the prescribed plan of action. It translates the plan into directives based on the latest information available from OBSERVE (2.0) and the inferred situation from ASSESS (3.0).

At a given organizational level, this function provides for the reception of plans and procedures concerning the tasks to be performed from PLAN (1.0), the identification of current activity (3.1), the scheduling of resources (3.2), and the generation of specific command directives (3.3). It is in this function that specific tasks are assigned to specific resources based on resource availability, task requirements and control procedures. This allocation process remains in place until the evolution is completed or until a condition exists for which the ASSESS (4.0) function indicates that a change is required or that the PLAN (1.0) is not going to be met. For the period of time that the PLAN (1.0) is being met, the generation of command directives in the performance of a given task uses information derived from the latest current tactical picture from OBSERVE (2.0), associated branching instructions from ASSESS (3.0), the corresponding task requirements, and the specific resource's capability. When the ASSESS (3.0) function recognizes the action is not meeting the plan, then either a new plan or an update will be issued by the PLAN (1.0) function. During the hiatus, task execution may be inhibited or additional ground lost due to inappropriate action. Recovery from this situation is critical. The EXECUTE (3.0) function provides the command directives for implementation by subordinate organizations and associated resources and, to other organizations, for information.

4.R RECEIVE PLANS, DATA AND STATUS

4.R.1 From PLAN (1.0)

Plan of Action for scheduling specific resources/tasks.

4.R.2 From OBSERVE (2.0)

Status for indications of plans being met/branching instructions (continue/branch/update).

4.R.3 From ASSESS (3.0)

Status data (current tactical picture) for command generation and branch selection.

4.1 IDENTIFY CURRENT COURSE OF ACTION

This function is the predetermined branching function. Based on the assessment of the current situation, this function selects from the predefined set of contingencies (or allowable actions), that which is deemed most appropriate or preferred. Any contingency that is not predefined or any situation not satisfied by a contingency requires a new plan or update to an existing plan. This latter condition is one outcome determined by the ASSESS (3.0) function. The selection of the current main branch is achieved via the ASSESS (3.0) function. The OBSERVE (2.0) function provides for branching within the context of the current main branch. The sub-branch selected needs to be known by ASSESS (3.0) to interpret the current tactical picture. This process involves the determination of the specific tactical and support requirements based on the action requirement of this contingency or branch. It also establishes rules for scheduling resources, identifies data requirements for control generation, and provides criteria for threshold settings.

4.1.1 Select Appropriate Contingency COA Based on Plan

4.1.2 Identify Tasks/Requirements

4.1.3 Initiate Adjustments

4.2 SCHEDULE RESOURCES

This function involves the process of mapping the tasks to available resources. The tasks to be mapped are related to the specific branch of the latest plan. The mapping process involves matching the task requirements to the capabilities of the available resources. It is then that specific commands are generated (4.3) for the implementation of the tasks at hand.

4.2.1 Determine Resource Availability/Capability

4.2.2 Assign Resources to Tasks

4.3 GENERATE COMMANDS

This function involves the direction of assigned assets (force units, surveillance assets, weapons, force countermeasures and non-warfare or support elements). It is the real time equivalent of plan generation but only involves specifying details for the currently active evolution. This function translates the data from OBSERVE (2.0) and the course of action selected by 4.1 into specific direction and tasking orders to be carried out by controlled resources. Equipment settings, sensor operation and platform positioning are specified to optimize performance under the existing environmental conditions and tactical situation.

These orders may be disseminated or used locally. The current direction is used by OBSERVE (2.0) to anticipate events that should be expected as a result of actions being directed.

4.3.1 Direct Change in Status, Posture, System Modes

4.3.2 Transform Data for Control

4.3.3 Document Command Directives

4.I ISSUE COMMAND DIRECTIVES, REPORTS/REQUESTS

4.I.1 To ASSESS (3.0)
Current branch for interpretation of tactical picture.

4.I.2 To OBSERVE (2.0)
Command Directives for archival and current direction purposes.

4.I.3 To External
Disseminate command directives/reports/requests to subordinate organizations and to others for information.

4.I.4 To SENSE (S.0)
Threshold Settings Criteria

S.0 SENSE

At given organizational level, this function provides for the reception of information from lower organizational levels, other resources, and the environment via various sensors, including communications links, and then transforms physical phenomena (S.1) into information representing sensory data and event data, and resource data (S.2) into information representing resource status parameters and conditions. (Messages from external sources listed with other command functions as inputs "X" may be handled through this function.) It is this function that provides data in various forms to the OBSERVE (2.0) function for characterization and the generation of the current tactical picture. The transformation of physical phenomena (S.1) into meaningful events occurs with the sampling of the environment with various methods of transduction and then under temporal synchronization from ACT (A.0), the data is processed. Significant departures from the environmental background represent detections when observe contacts are present. The generation of resource data represents the latest statistics concerning the resources available.

S.R. RECEIVE/SENSE OWN AND REMOTE SENSOR DATA

S.R.1 From Environment

Sensory Data: Acoustic, Electromagnetic, Navigation, Time, etc.

S.R.2 From Own and Other Resources

Resource Data and Sensed Data

S.R.3 From EXECUTE (4.0)

Threshold Settings Criteria

S.R.4 From ACT (A.0)

For Spatial/Temporal Synchronization of Sensors/Processing

S.1 GENERATE SENSORY/EVENT DATA

It is this function that provides sensory/event data from all available resources to the OBSERVE (2.0) function for characterization and the generation of a current tactical picture. This is achieved by sensing/formatting other resource data or by transduction, sampling and processing of own sensors or sensor units. This includes sensing Navigational and time data.

S.1.1 Sense Own Resource Sensory Data

S.1.2 Process Own or Other Sensed Data

S.1.3 Estimate Background

S.1.4 Set Thresholds

S.1.5 Generate/Format Threshold Crossing Events

S.I ISSUE DATA REPORTS

S.I.1 To OBSERVE (2.0)

Provide Sensory/Event Data

A.0 ACT

This function is where command directives from the EXECUTE (4.0) function are implemented to initiate action for the countermeasures. The settings for the control parameters are established in the EXECUTE (4.0) function.

At a given organizational level, this function provides for the reception of information in the form of specific commands from EXECUTE (4.0) for implementation (A.1). It is in this function that specific tasks are executed in a series of specific actions. It is this sequence of events that causes the actual effects on other organizations, resources and the environment.

This function also provides the means of spatial and temporal synchronization (A.3) to the SENSE (S.0) function and action feedback (A.2) to the OBSERVE (1.0) function. Through the action feedback process, some of the events detected by SENSE (S.0) can be anticipated or recognized as having been caused by the ACT (A.0) function. The spatial/temporal synchronization provides the means for determining the correct current tactical picture.

A.R RECEIVE COMMANDS

A.R.1 From EXECUTE (4.0)

Specific Commands for Implementation

A.1 IMPLEMENT COMMANDS

This function represents the execution of specific actions in response to commands and tasks.

A.1.1 Set Equipments

A.1.2 Actuate Weapons and Countermeasures

A.1.3 Operate Sensors

A.1.4 Control Platforms

A.1.5 Energize Simulators/Stimulators

A.2 GENERATE ACTION FEEDBACK

This function provides feedback for the OBSERVE (1.0) function within a given organizational level as to the status of actions by effectors occurring during the ACT (A.0) process. In this function, an expectation is provided for some of the event data in the SENSE (S.0) function.

A.3 SYNCHRONIZE ACTION

This function provides for organizational spatial/temporal synchronization that is used as a common reference between action and event data.

A.I ISSUE ACTIONS AND FEEDBACK DATA

A.I.1 To OBSERVE (2.0)

Data for Command Feedback

A.I.2 To SENSE (S.0)

Data for Temporal Synchronization

A.I.3 Effector Actions

On the Environment, etc.

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